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TRAINING FOR MANAGEMENT

THE discussion on training for management, arranged jointly by Sections F (Economics) and L (Education) of the British Association during the recent meeting in Liverpool, which was opened by Sir Charles Renold and Prof. R. S. Edwards, like other recent discussions, notably at conferences arranged by the Federation of British Industries, emphasized the importance of co-operation between industry and the universities in such training in order that the standard of management in industry may be raised. While industry should pay more attention to systematic training of its recruits, Sir Charles Renold urged that the most effective results would be obtained by co-operation between industrial companies and a university in running joint training schemes. The objects of such a training scheme for graduates entering industry, in his view, were to give the graduate the feel of industrial life and to help him to find his feet, and also to give him a general understanding of the basic features of the company's business, as well as the opportunity of developing so that his particular bent was revealed and the foundations were laid for specialized knowledge and experience.

Sir Charles thought it was important that as much as possible of the university man's training should consist of the execution of specific jobs for which he would be definitely responsible, and the scheme he suggested was one extending over three years, partly with an industrial firm and partly at a university. The trainees would be engaged by the company and would attend a university as sponsored students, where their training would aim at providing a background understanding of industry which would give point to the practical work, and also supply more specialized knowledge in fields where the chosen career made it desirable. Such a course would, he thought, enable the recruit to climb the ladder faster as well as improve the calibre of management, though it would only lay the foundations for general management, the capacity for which would come to light in later years.

Commenting on this scheme, Prof. Edwards said that, while there was room for major experiment, we have not yet reached the stage when the number of applicants of good quality exhausts the training facilities available. He believed that the universities could match any probable level of demand for postgraduate training in business administration; and if the demand for places increased rapidly, he thought it would be wiser to dilute temporarily the discussion method of teaching with more lecturing, rather than to establish new departments and additional posts and staff them at a level below what is in Great Britain regarded as appropriate to university work. If thirty or forty leading businesses each seconded one trainee to a university postgraduate course in administration in each of the next three academic years, industry could then judge for itself whether or not an academic year during business training was worth while. Prof. Edwards suggested that this was a scheme for which

Counterpart Funds provided by the United States under the Benton–Moody Amendments might very appropriately be used to the extent of contributing to firms seconding men for such postgraduate training in European universities a grant equal to half the salary of each man accepted for a course.

The contribution which training schemes of this type could make towards raising the calibre of management, avoiding frustration on the part of the recruits and in assisting industry to attract and keep men of the calibre it desires was generally recognized; but the difficulties that may arise in these proposals were not really explored. Both Sir Charles Renold and Prof. R. S. Edwards were emphatic that university graduates are not the only source of potential general managers, and Sir Charles said specifically that it would be fatal to the morale of an organization if it were believed that there was no chance of promotion from the 'shop-floor'. Prof. Edwards proposed that the scheme of seconding men to a university postgraduate course should not be limited to graduates. Nevertheless, in view of the increasing extent to which the abler pupils leaving school now enter the university, as one speaker reminded the meeting, it may well become in practice increasingly difficult for industry to promote its managers from the shop-floor, however wide open the door may remain at least in theory.

What this amounts to in practice is that selection is liable in future to take place to an overwhelming extent on leaving school: the managers in industry will develop in general among the group that enters the university. The significance of this factor seemed to be missed in the discussion, or the really startling indictment of the university graduate which Prof. F. W. Paish slipped out in opening the discussion would scarcely have escaped comment. In a reference to the qualities of the university graduate, Prof. Paish remarked that he is sometimes less teachable and less easy to discipline than those who have entered industry direct from school. Unless, however, the graduate carries with him from the university the inquiring mind, the very purpose of a university education has failed; what, above all, is expected of the graduate is not a mind full of facts but an open mind that has learned to handle facts and where to seek them. If the universities are not providing industry with men who have been trained to think, to be critical and to exercise initiative, but are supplying appreciable numbers of graduates with the closed mind of which Prof. Paish spoke, the discussion of training for management should start by inquiring very closely into the form of undergraduate training.

Postgraduate training will do little if the university has really failed to promote the imaginative consideration of the general principles underlying an intellectual career which A. N. Whitehead insisted is the chief function of a university in the preparation for such a career. It may well be, however, that training for management needs to be considered rather more closely in relation to undergraduate training generally, in view of the probability that industry will in future have to recruit its managers in the main from the university rather than the shop-floor. If confidence is to be maintained that a managerial career is open to all who can show that they possess the requisite capacity, it is in the university that there must be wide opportunities of acquiring the particular auxiliary techniques and the wide general knowledge that a manager may be called upon to exercise. This much is clearly recognized in the provision at the Imperial College of Science and Technology in London of general lectures on ends and means in science and on legal and economic subjects for postgraduate students of science and technology, and also in the curriculum of the new University College of North Staffordshire.

It should also be noted that at the Federation of British Industries Conference, at which he raised the question of the increasing dependence of industry on the universities for its managers, Dr. Eric Ashby also voiced the misgivings of many of his academic colleagues as to the extent to which management could be taught. There are techniques which a manager must use, and there is much technical knowledge which he requires in evaluating particular situations and making his decisions; but ultimately management is an art to be learnt by apprenticeship, by working and studying under competent practitioners of the art.

This aspect scarcely received sufficient attention in the discussion at Liverpool, and it is frequently ignored. Its importance, however, has been emphasized recently in several ways. It was apparent from the evidence submitted to the Select Committee on the Nationalized Industries that the misgivings with which some of the witnesses regarded the proposal to set up a Standing Committee for the Nationalized Industries to inform Parliament more fully about the industries, though not to control them, was due largely to fears that the quality of management in those industries would be adversely affected. Fuller public accountability would thus only be secured at the expense of managerial efficiency.

There is much to support this view in the latest report on the nationalized industries of Great Britain which has come from the Acton Society Trust*. Undertaken as a further study in decentralization, in extension of those already made by the Trust, the report is concerned especially with the changed functions and status of what are described as the operational managers, and above all, whether they are given sufficient freedom of decision to carry out their job satisfactorily. Inevitably, a measure of central planning, co-ordination and specialization involves some restriction of the operational manager's powers. The Acton Society Trust examines the crucial questions whether the actual restrictions are more than are necessary to achieve the desired co-operation, and whether the degree of restriction is such that the operational manager feels frustrated.

This examination of the practical possibility of reconciling the needs of central control and of local autonomy, with its frank facing of the question whether achievement of one means the sacrifice of the

* Management under Nationalisation: Studies in Decentralisation. Pp. 79. (London: Acton Society Trust, 1953.) 7s. 6d.

other, makes the report an admirable complement to that of the Select Committee. It should be said at once that this study of the position of an area general manager in the coal industry, of a power-station superintendent, and of district managers in the Road Haulage Executive and the Welsh Gas Board respectively is not a little disturbing. It indicates, indeed, some of the factors of which account should be taken before a sound judgment can be reached as to whether the need for greater public accountability is only a passing phase which the nationalized industries themselves will rectify as they become established and less disturbed by political debate. But it emphasizes also the extent to which critical and constructive thinking about the whole function and conception of management in industry is required if we are to achieve the degree of widespread co-operation and mutual understanding, particularly between the specialized types of manager now in existence, upon which effective modern management depends.

In these studies by the Acton Society Trust, the term 'decentralization' is used to refer only to the devolution of authority from the centre of the organization to the periphery. Their primary objective is to convey in concrete terms the actual impact of nationalization on the operational manager responsible for the day-to-day operation of a producing or service unit or units. The Trust believes that the views of the operational manager, which will not necessarily be shared at other levels of management, are facts which should be taken into account in planning or assessing any reorganization, for the problems of the operational manager are a vital factor in the future development of the industries.

Although the report attempts no more than sketches of the point of view of the four representative managers already indicated, the portrayal is done skilfully and with imagination; it should stimulate fresh thinking and provoke new ideas as to the dangers to be avoided and the objectives to be sought.

The major failure of the nationalized industries of Great Britain in regard to their operational management, in the view of the Acton Society Trust, is the failure of the boards to make it clear to the manager that appropriate action by the higher management will follow the operating results of his unit. As the report properly observes, judgment by results and the appropriate response to failure or success by the higher management may well be the best guarantees of efficiency and enterprise. "If the Boards fail to dispel the belief that no man will be removed no matter how inefficient, the present expectations of the public industries may never be realised."

That, of course, cuts right down to all levels and encounters a great difficulty in the fact that the boards are, almost without exception, the sole employers in a particular industry. Even without the difficulty of proving inefficiency before a formal committee, which the establishment of protective disciplinary codes usually means, finding a balance between reasonable security and adequate incentives is a formidable problem. The centralizing tendencies are carried further by the influence of Parliamentary accountability and the representation of consumers. The demands of a nationalized industry may, in fact, involve restrictions on management which are unique and which no board can easily relax without prejudicing the purposes for which public ownership was introduced.

Here lies the greatest need for fresh and constructive support, and it is interesting to note that very similar conclusions have been reached by other disinterested and detached observers. Sir Douglas Copland, in his presidential address to the Australian and New Zealand Association for the Advancement of Science at Sydney in August 1952, dealt with the broad question of authority and control in a free society; he commented on these same difficulties and suggested that the social scientist has a heavy responsibility for devising means of promoting initiative and of fostering the enterprising spirit in all fields of public administration. Extensions of authority and control require a solution of this basic problem if society is to remain free and enjoy the forms of collective enterprise required for economic progress and social welfare.

There is thus little in this report to justify the view that the problems of the operational manager can be dismissed as essentially 'teething troubles', and here the Acton Society Trust reminds us that the discussion is also concerned with the vital question—How are the managers of the future to be attracted and trained? There is already evidence that, in the nationalized industries and elsewhere, centralized organization fails to attract the able man, partly because it affords few opportunities for exercising initiative and responsibility. Unless managers are allowed to manage, it is vain to argue that until the able man turns up decentralization is impossible.

To recognize these conflicts is the first step towards an attempt to resolve or reconcile them. Any policy of decentralization for the nationalized industries must first attempt to understand and to reconcile the genuine conflict between the demands of Parliamentary accountability and public control on one hand, and the traditional conception of managerial initiative on the other. No concrete proposals are made in this report; but four lines of advance are indicated which, while primarily intended to stimulate thought about the nationalized industries, have their bearing on industrial management generally and on an aspect of training for management which was overlooked in the British Association discussion at Liverpool. First, it is suggested, a better balance should be sought between public accountability and financial responsibility on one hand and managerial flexibility on the other. Next, new methods are required of selection and training for management adapted to the needs of a large-scale organization. Third, and probably, in nationalized industry, most important, confidence must be strengthened between managers at all levels through regular contact. Lastly, attempts should be made to improve measuring techniques, by, for example, the development of new objective criteria enabling the superiors not only to judge their subordinates but also the subordinate managers to judge themselves.

Obviously training for management must take account of all these lines of thought, and above all of those new implications, largely unexplored as yet, of the conception of responsibility in industry. No scheme of co-operation between industry and the universities can of itself contribute much towards the establishment of that confidence throughout industry on which effective management largely depends, nor will it avoid frustration if from any cause those trained are not allowed to manage. Such schemes can, however, do much to provide industry with men who are competent to use their opportunities of establishing confidence and of working harmoniously and effectively with others, whether specialists or not, and who may be expected to contribute something to the constructive thinking about problems of decentralization and of the reconciliation of control and initiative upon which the Acton Society Trust and Sir Douglas Copland alike insist.

What is important, therefore, is that the limits of training for management should be clearly recognized, as well as its possibilities. There are techniques that can be acquired so that the trainee is better equipped to deal with the problems which he will encounter when he comes to exercise managerial responsibilities; but apart from this it could well be argued that every industrial recruit, at least of the status of graduate, should be given something of the training that Sir Charles Renold suggests. To give it solely to those intended for managerial posts may well have the very effect on morale, under present conditions, that Sir Charles wished to avoid.

For that reason it is possible that the most essential preparation for management is that which should be acquired in the normal course of a university education. Not a few of the most serious mistakes in organization and administration in Great Britain in recent years, whether in government or in industry, have been made through lack of the philosopher's habits of thought and his ability to view a situation as a whole and the changing effects on it of each individual action. Too often there have been neglected the simple principles of governing men which have been displayed so clearly by Sir Ernest Barker, for example, or illustrated by Commander A. H. Leighton in his book "The Governing of Men". That book, it may be noted, came from a university press, and if the universities have adequately discharged their fundamental task and supplied industry and government with men imaginatively alive to the human issues underlying the decisions they are called upon to make, who have been stimulated and trained to think strenuously about the great issues of right and wrong, of liberty and government, and who are capable of making balanced judgments, industry is unlikely to find it a heavy task, either alone or in postgraduate courses in collaboration with the universities, to supply whatever further training is required to enable its recruits to perform skilfully and magnanimously the varied technical or managerial tasks that may be set them. Alert, receptive and sensitive minds are the right basis for training in management, and when this is ensured there should be the less danger, either in industry or in government, of neglect of understanding, or failure to dig deep the channels of assent. There should then, too, be little danger of excessive preoccupation with either the selection or the training of managers and administrators deflecting the attention of industry or of government from the graver and more urgent problem to-day of securing the conditions in which effective management and administration are possible.

LEEUWENHOEK'S LETTERS

The Collected Letters of Antoni van Leeuwenhoek Edited, illustrated and annotated by a Committee of Dutch Scientists. Vol. 4. Pp. ix+384+28 plates. (Amsterdam: Swets and Zeitlinger, Ltd., 1952.)

THE stately progress of this opulent edition is severely deliberate; but happily no diminution of its initial vigour and purpose can be detected. Four out of the projected twenty volumes have now been printed, the first three appearing in 1939, 1941 and 1948. The preparation and publication of these four volumes, therefore, having extended over some sixteen years, the completion of so difficult and expensive an enterprise, if pursued at the same leisurely momentum, will not benefit many of us now living. The present Vol. 4 includes letters 70–81 inclusive (old numbers 37–42); but six of these are very brief communications of no scientific interest, though they are properly retained for the sake of completeness. The most important of the great variety of topics dealt with, arranged in chronological order from January 1683 to July 1684, explore problems of generation, the anatomy of the flea, spermatozoa as the source of the fœtus, histology of the blood, the flora of the saliva, histology of the epidermis, blood capillaries and lymph vessels, comparative histology of the lens of the eye in various vertebrates, red blood corpuscles of birds and amphibia, structure of negroid skin, structure of the brain in birds and mammals, and the scales of fishes such as the eel, and age determination thereby.

The letters are followed by an essay on Leeuwenhoek's ophthalmology written by Prof. W. P. C. Zeeman, in which the author claims that modern methods of investigation have "not been able to add much of essential importance" to Leeuwenhoek's researches on the lens capsule and lens of the vertebrate eye. Finally, there is Miss J. I. H. Mendels's very interesting discourse on Leeuwenhoek's command of his own language; but only those parts of this enlightening analysis which would be useful to the foreign reader have been translated into English. She rightly claims that Leeuwenhoek's Delft dialect is a valuable source of the spoken Dutch language of the seventeenth century, and is therefore of importance to the student of that dialect.

The volume is completed by useful bibliographies and brief lives of authorities quoted, and all the surviving original illustrations are reproduced together with relevant modern figures for purposes of comparison. There is a good index. Dr. A. Schierbeek of The Hague, whose energy and enthusiasm are inexhaustible, is the learned editor.

The complete and adequate English translation of all the letters will be gratefully welcomed by those unfamiliar with the Dutch tongue. Such textual

annotations as are necessary for the clarification of Leeuwenhoek's numerous difficult passages, and without which the translation would lose much of its value, are provided by some nineteen eminent authorities. Printer's errors occur, it is true; but when the sense is not compromised they may be left to the corrective pencil of the reader. On the other hand, the following mistranslations and errata have been noted: p. 5, par. 2, for 'edited' read 'published'; p. 11, Juny is Leeuwenhoek's Dutch and not English; p. 23, par. 2, insert 'which was the' before 'reason'; footnote 39, for 'two germinate' read 'paired'; footnote 41, for 'entwine' read 'radiate over'; p. 37, footnote 67, 'indissoluble' is obsolete in English in the sense of this paragraph; p. 49, line 2, for 'cause' read 'case'; p. 69, footnote 27, for 'who did not yet dispose of a staining-method' read 'without the assistance of staining methods'; p. 71, footnote 30, for 'the rule of dominants' read 'dominance'; p. 73, footnote 32, the nematode Leeuwenhoek saw in the frog was probably *Oxysomatium longespiculum* not *Oxyurus* (*sic*); p. 121, this letter is correctly dated in the reviewer's copy of the *Phil. Trans.*; p. 145, last line read 'dermis'; p. 175, line 11, read 'purgative'; p. 189, footnote 35, 'with' is redundant; p. 211, last line, for 'observing it in parcels' read 'observed its parts'; p. 213, footnote 7, this quotation is not literal but modified; p. 217, footnote 15, for 'laying' read 'lying'; pp. 241 and 311, why adopt the French 'mouches volantes' in an English translation instead of the Latin 'muscæ volitantes', which is the earlier equivalent in English scientific texts; p. 245, the 'black Moorish girl' was doubtless a negress—an assumption supported in the 1708 edition of Sewel and by the context; p. 259, the 'nerve-fibres containing marrow' are in English 'medullated nerve fibres'—*merghoudende* in Dutch and *markhaltig* in German; p. 265, line 2 from bottom, for 'flown' read 'flowed'; p. 337, Blasius's dates are *c.* 1625–92.

We heartily congratulate the Leeuwenhoek Commission on its courageous decision to continue its task at the same high level of production without flinching from the far greater difficulties which now confront them.

F. J. Cole

NUCLEAR STABILITY

Nuclear Stability Rules

By Prof. N. Feather. (Cambridge Monographs on Physics.) Pp. ix+162. (Cambridge: At the University Press, 1952.) 20*s.* net.

THE study of nuclear structure ntinues to attract the attention of a large and growing body of physicists; between one and two hundred papers are published monthly, each containing new information about particular nuclei. With such a mass of information produced at such a prodigious pace, the process of collecting, sifting, analysing and presenting the material in a manner which makes the details readily accessible and the general trends clearly discernible becomes a task of vital importance. Mere accumulation of data, however thorough and well-ordered, is not sufficient; nor is the occasional review which may present some aspect of the new information in relation to a particular theoretical background; and in both of these respects the needs of nuclear physicists have been well met in recent years. What is often wanted is a compact and comprehensive survey of a wide range of experimental material, and it is to the worthy task of providing such a survey that Prof. Feather addresses himself. Within the scope of a Cambridge monograph he presents a coherent, readable, up-to-date account around the theme of nuclear stability.

There are two distinct aspects of nuclear stability to be considered: first, the energetics—what modes of spontaneous disintegration are possible for a particular nucleus. Secondly, knowing a particular mode of disintegration to occur, and the energy change associated with it, the significant property of the process is the characteristic probability or rate. The major part of the book under review is concerned with establishing and examining regularities in the above two respects for the two commonest types of nuclear instability, α- and β-decay. In addition, the book opens with a short discussion of the practical limitations to the observation of instability, and an account of the range of charge and mass numbers for which stable nuclei occur. It concludes with a brief note about the instability of heavy nuclei as regards 'fission'.

Throughout, the author avoids sophisticated theorizing on the facts, adhering to his declared aim only "so to marshal the facts that the theorist is most likely to be inspired by valid—even 'correct'—ideas on contemplating them". Nevertheless, some theory does make an appearance; and if such a book is to appeal to readers other than specialists in this particular field, then the function of the theory both in the process of marshalling the facts and interpreting them must be clearly brought out, and it is questionable whether the author's choice and arrangement of material always serves this purpose well. For example, the regularities in α- and β-decay energies are particular manifestations of some features of the nuclear mass 'surface' (mass regarded as a function of the two variables A, Z), and can be more readily appreciated if some picture of this surface as a whole is presented, which would involve a discussion of data other than of the α- and β-decay processes themselves. In another respect, the presentation of detailed algebraical manipulations (particularly in Chapter 3), the interesting features would stand out more clearly if the details were omitted. In the treatment of regularities of life-times of α- and β-decay processes, the general theoretical interpretation of the dependence of decay probabilities on energy is, in both cases, assumed, and the information should therefore be presented in such a manner as to expose the regularities which are of interest because they are *not* accounted for by the straightforward part of the theory. In particular, the many diagrams showing the relationship between β-decay constant and energy could be condensed to a more compact presentation of the 'reduced' decay constants ('*ft*' values) for different β-emitters, in which the irrelevant energy-dependence has been removed.

A controversial issue inevitably raised by such a book is that of notation. Here one can commend the general restraint shown in introducing new terminology, and at the same time indicate where more drastic action would have been welcome. The specification of nuclei sometimes by the numbers A, Z and at other times by N (neutron number) and Z, and the corresponding duplication in the description of the 'even–odd' characteristics, are surely not both necessary; and the unconventional use of the word 'parity' in this connexion is sometimes un-

desirable. The phrase 'nuclear species' is scarcely an improvement on the now common 'nuclide'.

Many readers of this book may wish that the author had adopted a rather broader treatment, by incorporating a wider range of relevant experimental material (for example, the systematics of the masses of stable nuclei and their actual observed abundances are relevant topics); and also giving more indication of how the facts elicited are related to current theories of nuclear structure. However, this would probably have resulted in a much larger work, and Prof. Feather hints at the restraint he has had to exercise in order to keep within the limits he has set himself. In dealing with the "magic numbers", he remarks (p. 26), "the temptation is great to embark at once on an ambitious attempt to find their interpretation in a 'shell model' . . . that temptation we shall for the present resist". But by the time all the experimental material is presented, there seems to be no space in this book for this fuller interpretation, and the reader must content himself with the valuable presentation of the material itself. S. Devons

LOCOMOTION OF ANIMALS

How Animals Move

By Prof. James Gray. (The Royal Institution Christmas Lectures, 1951.) Pp. xii+114+15 plates. (Cambridge: At the University Press, 1953.) 16*s.* net.

About twenty-five years ago Prof. James Gray turned from his classic researches on cytology to start his investigations on a very different subject, the mechanics and physiology of the locomotion of animals. Since then the vigorous Cambridge school of research into this aspect of zoology has grown up around his pioneer work, and a large volume of literature records the results of its experiments and observations on all groups of the animal kingdom from Protozoa to Mammalia. Prof. Gray has not yet given the scientific world a book digesting and integrating the great mass of new knowledge that he and his colleagues have discovered; but in the meantime he has done something even more difficult—he has written a book for children that sets forth the basic principles of the subject clearly and simply to make a most fascinating story.

The book introduces animal locomotion with a consideration of certain simple laws of mechanics and, using the motor-car and the lever as familiar examples to lead up to the more complicated mechanisms of animals, shows that all locomotion is governed by the same mechanical principles. Muscular contraction is described; and the action of the motor and sensory nerves, and the proprioceptor sense organs, including the semi-circular canals, is demonstrated by analogy with the controls and dashboard instruments of a machine. After these foundations are laid, the remaining five chapters discuss animals themselves and develop the story of locomotion from swimming, through walking and running, jumping and creeping, to gliding and flapping flight.

Prof. Gray avoids writing-down, and by the aid of clear diagrams and interesting examples he makes his technical details easily understood and shows how the structure of an animal is correlated with its way of life, though he does not, of course, venture to speculate whether structure determines function or vice versa. His well-chosen illustrations of the various points that he makes hold the attention and are full of surprises for the newcomer to the subject. The chapter on swimming demonstrates how unreliable the eye is when observing movement, and shows the necessity for using recording instruments when accurate analysis of phenomena is desired. The speed of a fish darting through the water is much less than it appears to be; a trout dashing away with the fly and making the reel scream round is taking the line out at only 3 m.p.h., and a heavy salmon putting a pull of 1 lb. on the line necessitates a force of 12–13 lb. on the hands at the butt to hold the rod stationary. But the acceleration of a fish is great; starting from rest the maximum speed is attained in 1/20 sec., an acceleration of 140 ft. per sec. per sec. A 600-lb. sword-fish travelling at 10 m.p.h. and colliding head-on with a wooden ship moving at the same speed strikes it with a force at the tip of the sword of more than 4½ tons—the surprising thing is, not that the sword penetrates the wood, but that it does so without itself being smashed in the process.

Thus the theme is continued: the electrical field surrounding *Gymnarchus* that allows it to find its way through muddy water; the evolution of legs from fins; the paces of terrestrial animals; how a kangaroo could jump over St. Paul's Cathedral if its leap were proportional to that of a flea, and why it cannot; the mechanics of the snake's movements; the flight of pigeons, albatrosses and bats; ultrasonic echo-location; and the function of halteres.

The author says in concluding his book: "The more we learn about living animals, the more beautiful their activities appear; and in a human world so much concerned with ugly engines of destruction, the concept of natural beauty provides welcome relief". Here speaks the true naturalist in the best sense, and he has been so successful in expounding his subject that few who take up his book will be able to put it down until they have devoured it all. This is popular science as it should be, and one hopes that Prof. Gray's little masterpiece will have the wide success that it deserves.

L. Harrison Matthews

PSYCHOLOGY OF PERSONALITY

The Logic of Personality

By Bernard Mayo. Pp. 188. (London: Jonathan Cape, Ltd., 1952.) 10*s.* 6*d.* net.

The main virtue of Mr. Mayo's book lies in its trenchant logical analysis of the question: What is personality? He shows that certain meaningless questions about personality can be replaced by meaningful ones. At first sight this may not seem a very impressive contribution. We begin to see its importance, however, when we follow the author in tracing the consequences of his views for discussions of personality in relation to art, ethics, and certain linguistic usages, and to the cognitive bias in philosophical theories of perception. The book could be studied with profit by personality testers, factor analysts, thematic apperceptionists, and students of *Rorschachiana* and the new journal *Szondiana*.

Mr. Mayo's discussion is marred on occasion by curious ideas about the psychology of personality. He supposes that the psychologist is only concerned with indirect knowledge, for example, such as may be embodied in or derived from testimonials, not with direct interpersonal knowledge. He thus appears

to be confusing metaphysical with empirical analysis, an error he could have avoided by becoming familiar with modern interpersonal theory. Much blood has been shed over the hyphen in the word 'inter-personal'. The battle between hyphenated and hyphenless interpersonalists is an attempt to decide the question whether the basic datum is a more-or-less self-contained individual entity, on one hand, or *relationships* between persons on the other. If the basic datum for empirical study is a set of relationships with other people, as the hyphenless school of thought contends, then the searching for individual entities can be left to the metaphysician.

Mr. Mayo's ideas on the measurement of personality are limited to the notion of scales for rating opposite traits and do not therefore need to be taken very seriously. His views on the 'self' will provoke more criticism. He argues that an entity called 'the self' is based on bad grammar, because there is no precedent for the use of the word 'self' as an independent noun capable of being the subject of a verb. He asserts furthermore that the problem of the self, even if it were genuine, would be irrelevant to the question of personality. This dismissal of an empirical problem as a verbal error is too facile a solution. One may add that in view of the uniqueness of the notion of self an argument based on lack of precedent scarcely carries conviction.

It is a pity Mr. Mayo has not confined himself to purely logical or philosophical questions. His failure to prevent the intrusion of empirical problems into a formal discussion spoils an otherwise valuable essay.

JOHN COHEN

HYDRODYNAMICAL THEORY OF DETONATION AND SHOCK WAVES

Detonation in Condensed Explosives

By J. Taylor. (Monographs on the Physics and Chemistry of Materials.) Pp. xi+196+10 plates. (Oxford: Clarendon Press; London: Oxford University Press, 1952.) 25*s*. net.

État actuel et valeur de la théorie hydrothermodynamique des explosions et des chocs

Par Dr. S. Travers. Première partie: Les ondes de choc pur et la compressibilité par choc sans combustion. Pp. v+116. 900 francs. Deuxième partie: L'Épaisseur des ondes de choc et le mécanisme de l'inflammation dans les ondes de combustion. Pp. ix+294. 1900 francs. (Paris: Éditions Eyrolles, n.d.)

THE theoretical and experimental studies of explosion and detonation carried out during the War and afterwards have served to focus attention on the physico-chemical changes occurring in the reaction zone of an explosive, and have led to a more precise formulation and extension of the classical hydrodynamical theory of detonation. It will be recalled that the simple form of the theory assumes the whole chemical reaction providing the energy necessary for the detonative process to occur within a narrow zone, the detonation front, moving with uniform velocity into the stationary explosive. Chapman and Jonguet further assumed that disturbances in the gas immediately behind the front travel at the same speed as the front, giving rise to a progressive wave of finite amplitude. It is clear, however, that the velocity of detonation must be influenced by the mechanical reaction of the gases streaming away from the front on the gas immediately behind it, and Taylor has formulated and solved the hydrodynamical equation for special cases where the flow field has symmetry.

Another important development relates to the behaviour of shock waves, produced with and without combustion, in solids, liquids and gases. The work of Hugoniot on shock waves in air has been extended by Becker to liquids and by Travers to solids, while Taylor has dealt with the case of blast waves produced by the release of a very large amount of energy unaccompanied by the generation of gas.

These theoretical advances have been accompanied by improvements in the experimental methods for measuring explosion and detonation velocities, and for observing the sequence of events both before and after the passage of explosion waves. As a result, we now have a much better understanding of the physical and chemical changes associated with explosion and detonation phenomena, and it is possible, with some confidence, to design and develop new explosives to meet the more exacting specifications demanded to-day by industry and the Services.

The two books here reviewed deal with somewhat different aspects of the subject. In "Detonation in Condensed Explosives", Mr. Taylor gives, within the compass of some two hundred pages, a brief description of the propagation of detonation in condensed explosives and an outline of the methods for calculating the numerical values of the detonation parameters. The examples quoted are chosen from commercial blasting explosives and much of the data has been obtained in the research laboratories of the Nobel Division of Imperial Chemical Industries, Ltd.

The ground covered in the monograph is extensive, and the theoretical treatment is in consequence somewhat superficial. The chapters on the hydrodynamical theory of detonation and on detonation in explosives where products may consist of gases only or may include a condensed phase are, however, clearly and concisely written and the methods of calculation are carefully explained. The text is well illustrated and a short bibliography is provided.

The two volumes by Dr. S. Travers are compiled from papers in the "Mémorial de l'Artillerie française", and are devoted to a detailed examination of the hydrodynamical theory of explosion and shock waves. The first volume deals with pure plain shock waves produced by mechanical compression without combustion, the basis of the treatment being the work of Hugoniot on waves in air and of Becker on waves in liquids.

The second volume deals with the dimensions of shock waves and the mechanism of inflammation in combustion waves, and contains an excellent historical review of the early work of Rankine, Riemann, Rayleigh, Chapman and Hugoniot.

Dr. Travers has generalized Becker's treatment to include the case of shock waves in solids and gives a method of graphical representation which provides an admirable picture of the physical changes occurring in the case of waves produced with and without chemical reaction.

The mathematical treatment of the complex phenomena associated with detonation is clearly and concisely presented, and references to the literature are complete up to 1953.

D. M. NEWITT

THE PLATINUM METALS

By A. R. POWELL, F.R.S.

IN April 1803 there appeared in the window of a mineralogist's shop in Soho an anonymous leaflet offering for sale a new metal called palladium. In the following year William Hyde Wollaston announced his discovery of another new metal which he called rhodium, and he afterwards admitted in a letter to *Nicholson's Journal* (dated February 1805) that he was the discoverer of palladium and the author of the anonymous advertisement. To celebrate the triple jubilee of Wollaston's announcement of the discovery of palladium, the Institution of Metallurgists is organizing an exhibition of the platinum metals at Grosvenor House, Park Lane, London, W.1, in the week beginning October 19. This exhibition, which will be opened by H.R.H. the Duke of Edinburgh, will illustrate the history of the platinum metals during the past 150 years, the great part they have played in the development of the chemical and electrical industries, and their modern scientific, technical and æsthetic uses. The exhibition will be open free to the general public during October 22–24 between the hours of 10 a.m. and 8 p.m.

Wollaston is now rightly regarded as the greatest pioneer in the platinum metal industry, since he was the first to bring a trained analytical mind to the problem of obtaining malleable platinum. The first account of the existence of platinum in the New World was published by Don Antonio de Ulloa in 1748, and the metal was first recognized as a new element by the Swedish assayer, Scheffer, in November 1751. In the following fifty years many workers in Europe studied the new metal and endeavoured to bring it into a coherent malleable form. W. Lewis, A. S. Marggraf, C. von Sickingen and Delisle were among those who published important observations on the metal; but it was not until about 1786 that Pierre-François Chabaneau, working in Spain in collaboration with the brothers de Elhuyar, succeeded in solving this problem; the methods they used, however, remained a close secret until the early years of this century, when an account of them was discovered among some old archives in Seville.

Working independently in Great Britain, however, Richard Knight discovered "a new and expeditious process for rendering platinum malleable" which he published in the *Philosophical Magazine* in 1800. Whether this publication was the incentive which prompted Wollaston to turn his attention from medicine, in which he graduated at Cambridge, to the study of the platinum metals is not known with certainty; but the fact remains that in this year he abandoned his medical practice and devoted the greater part of his energies to investigating the platinum metals. At this time the refining of the native alluvial platinum grains from Colombia was based on purely empirical observations. Wollaston, however, set himself the task of studying the chemical procedures of refining in a scientific manner, and the first fruits of this work were the discovery of palladium and rhodium. Almost simultaneously his friend, Smithson Tennant, working in Cambridge, discovered iridium and osmium and published his work in 1804. It was not, however, for another forty years that the Russian, Karl Klaus, working at the University of Dorpat, found the last of the platinum group of metals, ruthenium, in the osmiridium residue remaining after the aqua regia extraction of Russian platinum mineral. Ruthenium occurs only in very small proportions in Colombian platinum mineral, and this fact probably explains why it was not detected by Wollaston or Tennant.

Wollaston thus may be said to have been the first to undertake a systematic investigation of the complex problems involved in the refining and fabrication of the platinum metals. Not only did he succeed in devising scientific methods for their purification, but he also worked out procedures for the consolidation of platinum sponge into ingots of consistently high quality, and for many years carried on a profitable business in supplying platinum ware for use in the laboratory and in the concentration of sulphuric acid. The details of his methods of fabrication were kept secret until 1828, when he revealed them in the Bakerian Lecture to the Royal Society only about a month before his death on December 22.

By this time the beginnings of the present large platinum industry may be said to have been laid. In Britain, Percival Norton Johnson, assisted by his brother-in-law, Thomas Cock, had undertaken the business of platinum refining and fabrication which is now carried out by the firm of Johnson, Matthey and Co., Ltd. In Russia, the discovery of platinum in the Urals in 1819 was followed by the setting up of a platinum refinery at St. Petersburg under the direction of P. A. Sobolevsky. In France, Bréant and Couturier started work in 1812 and had a very flourishing business in supplying platinum ware to Western Europe between 1820 and 1837; they were succeeded by Desmoutis, who was joined by Quennessen about fifteen years later. In Germany, the great Heraeus business was founded in 1851, and the Deutsche Gold und Silber Scheide-Anstalt in 1873 under the name of Roessler.

In the past hundred years or so, the major uses of platinum and the platinum metals have been based on the high melting point and general chemical inertness of the metals. Platinum crucibles for chemical laboratory work were in demand from a very early date; much of the Spanish output made under the direction of Chabaneau went to make platinum apparatus for the great European chemists, and the work of meeting this demand was carried on by Wollaston, and later by Bréant and Couturier. Platinum began to be used for making jewellery in the eighteenth century, the work of the French goldsmith Janety being especially famous. Undoubtedly the first use of platinum on a large scale was for coinage; between 1828 and 1846 nearly half a million ounces of platinum were coined in Russia as 3-, 6- and 12-rouble pieces, and this currency was withdrawn only because a serious fall in the price of platinum caused fears of extensive counterfeiting.

The first use of platinum in the chemical industry was for making boilers for concentrating the dilute sulphuric acid made by the lead-chamber process; for this purpose Wollaston fabricated, between 1805 and 1818, no less than sixteen large boilers each weighing between 322 and 477 oz. Even to-day platinum boilers are in use for the preparation of the purest concentrated acid for analytical purposes. Probably the next important industrial use of

platinum was as a catalyst, supported on magnesium sulphate or asbestos, for the manufacture of sulphuric acid by the contact process; vanadium catalysts have, however, largely supplanted platinum for this purpose owing to their lower price and inertness towards impurities which poison the platinum, but platinized silica gel is still used in some contact acid plants where a high quality of acid is required and relatively pure sulphur dioxide is available.

To-day platinum and platinum alloys are extensively used for melting high-grade optical glass and for making fibre glass, for precious metal thermocouples for the measurement of high temperatures, for electrodes for making persulphates for the manufacture of hydrogen peroxide, and for spinnerets for the production of artificial fibres. The electrical industry, too, is a very large user of the platinum metals in the form of contacts of all kinds, and as resistors for electric furnaces for operating above 1,000° C.

The catalytic properties of the platinum metals are also being exploited more extensively. Platinum and platinum–rhodium alloy gauzes are exclusively used for the manufacture of nitric acid by the ammonia oxidation process of Ostwald, and only recently it has been discovered that platinum dispersed on an alumina, silica or a silica–alumina base can be used in the vapour phase re-forming of the lighter petroleum fractions to produce high-octane motor spirit with superior anti-knock properties. Palladium, too, is finding wide applications as a hydrogenation catalyst in numerous organic syntheses. Recent American work has shown that palladium deposited on alumina is a very active catalyst for the reduction of anthraquinone to the corresponding hydroquinone, which can then be oxidized with air back to the quinone with the formation of hydrogen peroxide, a reaction first developed in Germany during the recent war for the manufacture of hydrogen peroxide for *V2* rockets.

Although the platinum metals, with the exception of osmium, are highly resistant to oxidation at room temperature, ruthenium, palladium, rhodium and iridium, even in the massive form, tarnish readily on heating to temperatures above 500–600° C.; but the last three become bright again at temperatures of the order of 1,100–1,200° C. owing to the volatilization or decomposition of the oxide; ruthenium, however, continues to oxidize with increasing rapidity with rise in temperature owing to the formation of the highly volatile tetroxide. Platinum alone of this group remains untarnished on heating in air up to its melting point; but nevertheless it appears to be oxidized at high temperatures in air with the formation of an unstable volatile oxide which decomposes to the metal at slightly lower temperatures; this is the cause of the bright spangles of platinum often seen on the refractory surfaces close to the platinum windings of small resistance furnaces which have been operated for long periods. That an oxidation process is the cause of this phenomenon is proved by the fact that no such volatilization occurs in a vacuum or in reducing or inert atmospheres, and if the refractory surface is kept fairly cool the platinum is deposited in a black form which contains several per cent of oxygen.

Russia and Colombia remained the chief sources of the platinum metals until about the period of the First World War, when the large increase in the output of nickel and copper from the Sudbury mines in Canada combined with improvements in the refining process resulted in large amounts of the platinum metals becoming available in the residues from the Mond process of refining nickel and, later, in the anode slimes from the electrolytic refining of the nickel and copper. The amount of the platinum metals produced from this source rapidly increased during the next decade until it reached an average of about 250,000 oz. per annum, at which figure it has remained.

In the middle 1920's large deposits of platinum ores were found in various parts of the Transvaal, principally in the Potsgietersrust, Lydenburg and Rustenburg areas, but by about 1930 only the Rustenburg area remained as an active producer. The output from this area has risen steadily until it is now about as large as that from Canada. The Merensky reef, which surrounds the Bushveld igneous complex in the centre of the Transvaal, is the principal source of the platinum metals; here they occur chiefly in combination with sulphur, arsenic and antimony in a norite rock heavily impregnated with chromite and containing nickel and copper sulphide minerals. In addition to sperrylite (platinum diarsenide), first found in the Sudbury nickel ores, and laurite (ruthenium sulphide), the South African platinum ores contain the new minerals, cooperite (platinum monosulphide), braggite (platinum–palladium–nickel sulphide) and stibiopalladinite (palladium antimonide). The platinum metals occur in these ores roughly in the proportion: platinum 100, palladium 55, rhodium 6, ruthenium 13, iridium 1, osmium 1.

Small alluvial deposits of platinum were discovered in Abyssinia in the late 1920's and much larger deposits in the Goodnews Bay district of Alaska in 1936. The Alaskan alluvial concentrates are remarkable in that they contain a high proportion of iridosmine, which has an unusually high content of iridium and a low content of osmium (only about 10 per cent). The Tasmanian alluvial deposits of osmiridium are now practically worked out; but considerable quantities of osmiridium, associated with native platinum and laurite, are recovered from the heavy black sands which collect on the corduroy tables during the treatment of the gold banket ore from various mines in the Witwatersrand area of the Transvaal; the precious metal concentrates obtained from this source contain up to 20 per cent of ruthenium with 30–40 per cent of osmium and 25–30 per cent of iridium, but are practically free from rhodium.

UNCERTAINTY, EXPECTATION AND DECISION IN BUSINESS AFFAIRS

DURING the recent meeting of the British Association in Liverpool, Section F (Economics) held a symposium on "The Logic, Philosophy and Psychology of Business Decision-making under Uncertainty", the main focus for discussion being Prof. G. L. S. Shackle's book, "Expectation in Economics" (second edition; Cambridge University Press, 1952). A day and a half were given to the discussion. Prof. Shackle, and many other economists, feel that the process by which a business-man reaches a decision depends very little, if at all, upon the rational assessment of probabilities which orthodox theory in the past assumed. But, of course, once

economic theory departs from mathematical probabilities it is committed to the exploration of processes in which complexity, subtlety and even mystery are the most evident features; and yet decisions are made, and in the mass these decisions show trends and patterns which suggest that they are not altogether unamenable to rational investigation. The decisions obviously bear some relation to the facts, but they also bear a relation to the temperamental characteristics of the business-men who make them. Perhaps the object of the symposium might be described as that of discovering a bridge between these two very different terrains.

The present report will indicate briefly how each of the speakers at the symposium interpreted his part of the discussion. Then the treatment of a number of common themes will be described. The contributors and their topics were as follows: Prof. W. B. Gallie (University College of North Staffordshire), uncertainty as a philosophical problem; Dr. D. J. O'Connor (University College of North Staffordshire), uncertainty as a philosophical problem; Dr. I. J. Good (London), the appropriate mathematical tools for describing and measuring uncertainty; Prof. G. P. Meredith (University of Leeds), methodological considerations in the study of human anticipation; Prof. C. F. Carter (Queen's University, Belfast), theories of expectations; Prof. B. R. Williams (University College of North Staffordshire), the impact of uncertainty analysis upon economic theory, illustrated from the theory of profit; Mr. A. D. Roy (Sidney Sussex College, Cambridge), the possibility of empirical testing of alternative theories of uncertainty; and Prof. G. L. S. Shackle (University of Liverpool), summing up of the discussion.

Prof. Gallie's paper was concerned with viewing Prof. Shackle's book in a perspective of scientific method, philosophy and sociology. He made the valuable point that, whereas philosophy has done much to systematize our views on moral wisdom, little or nothing has hitherto been done to systematize our accumulated prudential wisdom.

Dr. O'Connor, while accepting Shackle's concept of potential surprise, stressed the need for establishing a relation between this mental state and the objective credibility of the hypothesis under consideration. In his view the reliability of an expert judgment is "latent in the funded and assimilated experience of the expert". He opposed the assumption that there are features of human behaviour, individual and social, which are in principle unpredictable, but did not indicate how he would deal with those novel situations which form the basis of Shackle's renunciation of frequency as the factor determining credibility. This paper may be described as viewing Shackle's theory as a possible successor to the out-moded Hedonic calculus.

Dr. Good's paper was tolerant, shrewd and suggestive. It laid bare the numerous subtle and complex decisions which the mathematician must make in probability problems before he ever puts his symbols on paper, and he went behind these decisions again to the underlying theoretical and in some cases metaphysical assumptions to which the mathematician commits himself. Concerning the crucial relation between subjective degree of belief and numerical probability, Dr. Good opened out an important possibility in this remark: "The introduction of numerical probabilities does not imply that a degree of belief is always or even usually at all precise". This clearly suggests that a useful correlation may be established between a discontinuous series of degrees of belief and a continuous series of numerical probabilities. The paper stressed the importance of constructing axiomatic systems in this field, and indicated the diversity of practical applications of such systems.

In the next paper, Prof. Meredith discussed Shackle's function $\varphi(x,y)$ as an essentially psychological concept, and indicated the experimental problems in its empirical validation. Shackle's variables φ, x and y must be regarded as scales to be calibrated by experimental means. The variables may be discontinuous quantities, in which case Shackle's use of the differential calculus would be inappropriate. There may be several qualitatively different varieties of probability, and a probability may in many cases not be capable in principle of being expressed by a single number, but rather by a pattern of propositions, "the pattern of evidence of rational likelihood". Prof. Meredith's paper was illustrated by a model constructed to facilitate the discussion of Shackle's φ function (see Fig. 1). In this model x represents values of the various possible outcomes of a business venture ($z = -x$ represents losses). y represents the 'degree of belief, measured inversely as potential surprise' which the individual attaches to the various outcomes. φ, orthogonal to the x,y plane, represents the mental stimulus or 'interest' afforded by the various pairs of x,y values. At 0, and for a certain 'inner range', zero surprise is attached to small gains and losses. Maximum surprise, or 'impossibility', $\overline{y}$, is attached to very high gains and losses. The basin-shaped curve represents the impact of the business venture on the mind of the enterpriser and reaches maximum φ-values at two points—the 'focus-outcomes', representing maximum stimulus and deterrence, and determining the decision made; these are, in general, at intermediate values of x and y. The contours of the surface are characteristic of the individual's temperament. The continuous surface of this model implies continuous variables.

Prof. Carter explored the implication of discarding the continuous variables in Shackle's theory, and replacing them by discontinuous steps. Numerical measures must then be replaced by rankings. This raises a fundamental difficulty for Shackle's model, since "It is a logical impossibility to devise a means of compounding two pure rankings (or one ranking and a numerical index) to make another unique ranking". Prof. Carter demonstrated by a series of examples the novel kind of reasoning to which such an assumption would commit us.

Prof. Williams cast his net both wide and deep in the fundamentals of economic theory. He contrasted static theory with its assumption of equilibrium conditions as a basis for rational decisions at the price of unreality, with dynamic theory with its implications of change and uncertainty, and its need for theories of probability. The economist's habit of making psychological assumptions carries with it the need for consulting psychologists and sociologists. He welcomed Shackle's theory as an attempt to provide a new conceptual framework of "expectational dynamics". The rest of the paper was an inevitably somewhat technical discussion of the impact of expectational dynamics upon Keynesian theory with particular reference to profit. Prof. Williams closed with a plea for a sociological analysis of the goals of business firms and organizations within the socio-political system.

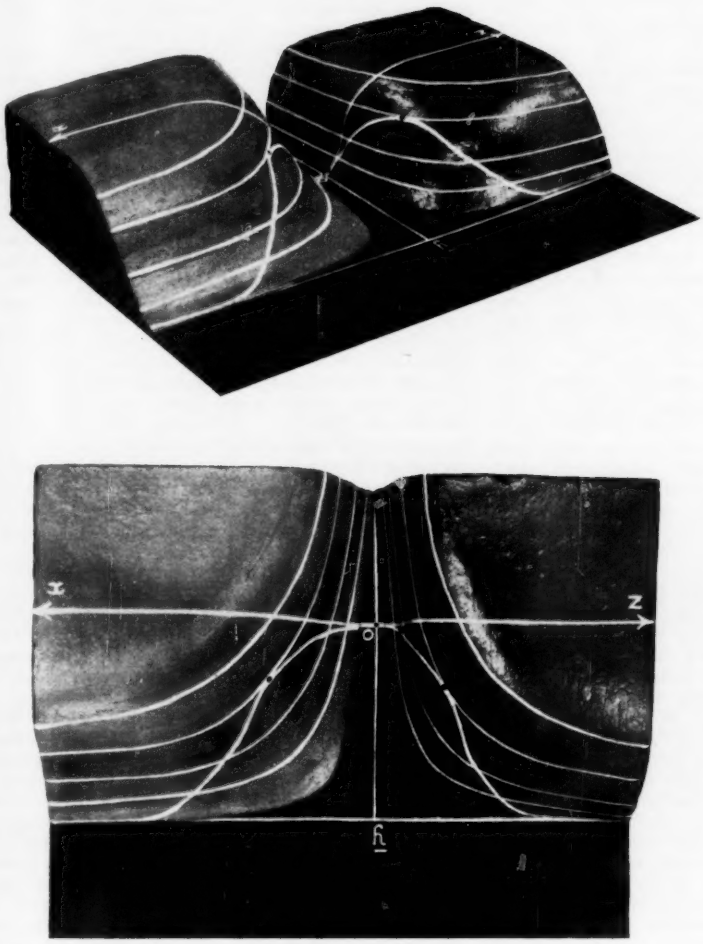


Fig. 1. Model of the Shackle function $\varphi(x,y)$

Mr. Roy attempted in his paper to specify actual methods by which different theories of uncertainty might be empirically tested. The link between past events and future outcomes is too tenuous and varied to allow of the elimination of what methodologists call the "intervening variables" of motive and expectation, but how can different theories of expectation be tested? The first suggestion would be a statistical analysis of economic time series. The second would be by laboratory experiments on individuals placed in situations which mimicked as far as possible those confronting the typical business-man. Neither of these is promising. Mr. Roy recommended the compilation of individual case-studies of decision-takers in action by a research worker living in constant daily touch with the business-man, and having access to all the necessary information and business text-books to throw light on the latter's decisions. Mr. Roy indicated the methodological difficulties in the use of such data for discriminating between alternative theories of uncertainty.

Prof. G. L. S. Shackle surveyed the discussion, and has prepared the following statement relating to his comments: If we understood how decisions are made, we should understand how history is made. So far as this is true, it is rather obvious. Yet decision-making, the focal creative psychic event where knowledge, thought, feeling and imagination are fused into action, seems to have received only the most casual glances of scientific men and other scholars. Mathematics has shown in probability theory how to derive knowledge concerning aggregates of future events from aggregates of past events, but this technique is irrelevant to personally unique and crucial occasions of decision by an individual. Frequency-ratios are knowledge and have nothing to do with uncertainty. The individual can choose only between imagined and not between realized experiences, for when an experience is actually proceeding it is too late to choose something else. Thus decision must, it seems, be guided or determined by the thrust of imagined and anticipated enjoyments and distresses.

The relevant, legitimate and useful question for a person to ask himself, when his decision on this course of action, rather than that, will swing the whole evolution of his affairs into a different path, is not: How can I add together all the rival, mutually exclusive hypothetical outcomes of this course of action? for the result of such addition would be meaningless; and the question is not: What *will* be the result of this course of action? for that cannot be known. The question is: What is the most exciting result that I can imagine this course of action as capable of producing, and again, what is the most alarming result?; where excitement and alarm each depend on two matters, the face-value of any hypothetical outcome in question, and its plausibility; and if we are to consider a hypothesis *by itself*, the measure of plausibility must be something radically and essentially different from numerical probability, which depends for its meaning and existence on the viewing of hypotheses in their gregarious collectivity. By a line of thought which is too long to reproduce here, I have been led to invert the problem and adopt a measure of *disbelief* instead of a measure of

positive confidence. The consequences are far-reaching.

If the line of ideas, the general direction only of which I have space to indicate, is to lead beyond a mere theoretical construction and make a solid contribution to knowledge, the interest and effort of philosophers, logicians, mathematicians, psychologists and economists will be needed for the intensive exploration of a territory the outlines of which were so brilliantly mapped by the seven contributors to the symposium at Liverpool.

So much for the distinctive features of the individual contributions. The following concepts and themes recurred in a number of the papers, and these suggest the movement of thought from which new developments in expectation theory may emerge.

Dissatisfaction with the frequency theory of probability. Decisions have often to be made concerning novel and unrepeated ventures. To these any frequency measure of probability is inapplicable; but even where it is theoretically applicable, there is a growing disbelief in the facile assumption that business decisions are based upon it.

The realization of the need for greater psychological realism on the part of economists. In a world in which the irrationality of man is everywhere manifest, it does seem somewhat naïve to assume that the business-man, of all people, is gifted with some unique degree of rationality which would give a mathematical sanction to his daily business decisions. It should, however, be pointed out that the word 'rational' itself demands some scrutiny. It is used to mean either 'effective' or 'ratiocinative'. There is a sort of practical rationality, or expertize, which depends upon years of experience rather than upon ratiocination. It is this which gives some measure of cogency to the degree of belief which the expert accords to the particular proposition.

The magnitude of the methodological problem. This is multifarious, and includes the relations between the social and the individual, conception and action, continuity and discontinuity, single and multiple causation, and a host of other relations.

The bearing of causative contexts and conceptual frameworks. The isolated business decision is probably a fiction. Decision arises out of the conceptual framework of the individual, and takes place within his socio-economic context.

The role of the conceptual model in theory-making. Theory attempts to simplify and clarify the welter of facts. It can do this only by setting up relatively self-contained abstract models; such a model, if it is to survive, must possess three features: internal consistency, as determined by logical analysis; validity, as determined by empirical tests; and power, as determined by its utility in both clarification and prediction.

The problem of quantification. This is an aspect of the validity problem, for in comparing empirical data with predicted outcomes there is a direct comparison of quantities. The theory of measurement is far from complete; even the physicists have their problems of metrology. Psychometrics and econometrics present problems of even greater complexity, but these are a challenge rather than a ground for pessimism.

A growing need for an adequate calculus of discrete quantities (as against the calculus of the arithmetical continuum). This may not be difficult for the pure mathematicians, but the users of mathematics would need to acquire new habits of thought, as well as new modes of calculation. The landscape model of Shackle's function in the accompanying illustration would have to make way for a model of steps and movable platforms.

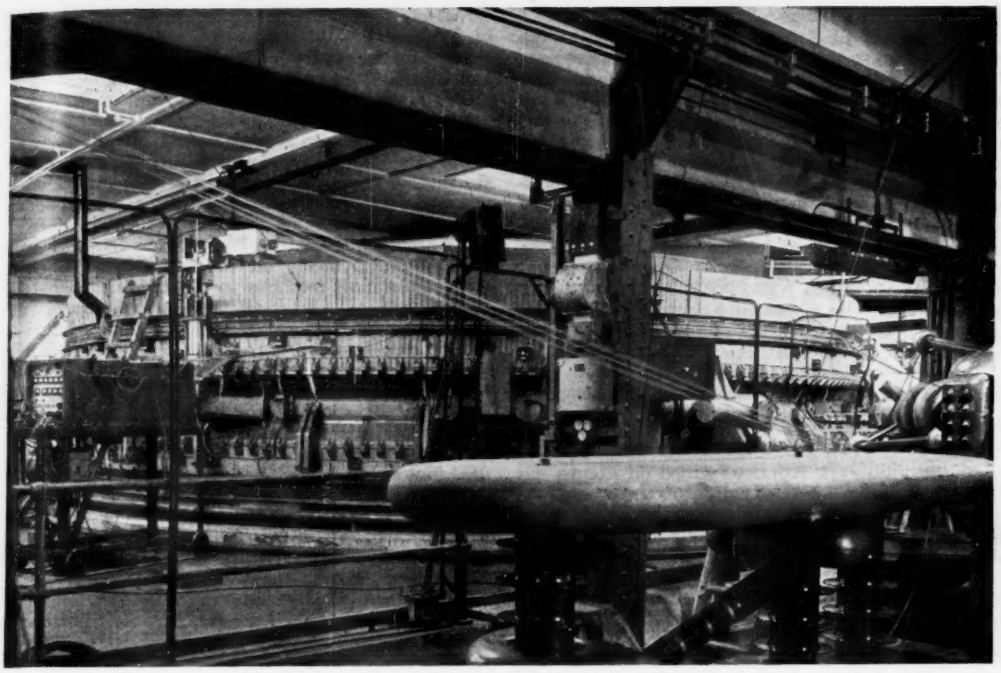
G. P. Meredith

PROTON SYNCHROTRON OF THE UNIVERSITY OF BIRMINGHAM

THE proton synchrotron in the Physics Department of the University of Birmingham is now able to accelerate particles to an energy of 1,000 MeV.; it first operated at full energy on July 16. A greater energy than this is known to have been reached artificially only in the United States, where the Brookhaven 'Cosmotron'[1] gives protons of an energy of 2,300 MeV. These two machines, together with a rather larger proton synchrotron approaching completion at Berkeley, California, are designed to provide experimental facilities for nuclear physics in an energy range above that which is economic for synchro-cyclotrons. Future proton synchrotrons, planned to incorporate the new strong focusing principle, will probably extend the energy scale considerably further.

The Birmingham synchrotron has been developed from the original proposals of Oliphant, Gooden and Hide[2], whose aim to reach a proton energy of about 1,000 MeV. was, just after the Second World War, ambitious but not unreasonable. Detailed design began in 1946 with the aid of a grant from the Nuffield Foundation, and construction started in 1947. The project was under the guidance of Prof. M. L. Oliphant until he left the laboratory in 1950, and, since then, responsibility for the development and testing of the machine has been in the hands of the present head of the Department, Prof. P. B. Moon. The undertaking has been financed mainly by the Department of Scientific and Industrial Research, without the support of which the project could scarcely have been undertaken by a university department. Several large and important parts of the equipment, such as the motor-generator, vacuum sections and high-tension generator, were supplied by outside firms; but the main technical responsibility has been undertaken throughout by the Department of Physics, and much of the actual construction was provided by the departmental workshops. The very considerable technical effort necessary has been supplied over six years by a large number of physicists and assistants, many of whom are no longer in the laboratory to witness the successful outcome of their work.

The first notable feature of the Birmingham synchrotron is its size. This is not shown to advantage in the accompanying photograph, since the machine had to be built within the fairly small space available in the Nuffield Research Laboratory, which was designed for (and still houses) the University 60-in. cyclotron[3]. The illustration gives a general view of the magnet (810 tons), which is built of C-shaped steel laminations $\frac{1}{4}$ in. thick, arranged in a circle with the annular gap outwards. The diameter of the mean horizontal orbit in which the protons circulate is 900 cm., and the magnetic field necessary to keep a proton of an energy of 1,000 MeV. moving in an orbit of this size is 12,500 gauss. Power for the magnet is supplied by a motor-generator set developing



General view of the proton synchrotron of the University of Birmingham, showing magnet, vacuum system, radio-frequency power amplifier and injection apparatus

1,100 V. which is connected to the air-cooled coils of the magnet at the beginning of the magnetic cycle. The magnet has an inductance of 0·1 H. and a resistance of 0·01 ohm, and a peak current of 12,500 amp. (corresponding to a field of 12,500 gauss in the magnet gap) builds up in the coils in 1 sec. The field excitation of the generator is reversed to limit the peak current and to reduce the current quickly to zero; when the current has passed its peak, most of the energy stored in the magnet feeds back into the motor generator, which has on its shaft a 36-ton flywheel for energy storage. The magnetic field-cycle repeats every 10 sec.

The magnet gap is 21 cm. high and contains a sectionalized porcelain vacuum tube of internal dimensions 10 cm. by 36 cm.; a pressure of 8×10^{-7} mm. is maintained by five diffusion pumps each with a speed of 2,000 l./sec. through a water-cooled baffle. A pulse of protons is shot tangentially into the vacuum system from a Cockcroft–Walton high-tension generator just after the magnetic field begins to rise. The injection energy is 460 keV., and the protons begin to move in a magnetic field which for this energy gives their path a radius of about 450 cm. On their way around the vacuum system the particles pass through an accelerating electrode ('cee') to which a radio-frequency voltage is applied; for each revolution the proton energy may be thus increased on the average by about 200 eV. This energy increment is just that required to maintain the particles in the mean orbit as the magnetic field rises. There must, of course, be synchronism between the applied radio-frequency voltage and the circulating protons, and as the particles speed up the applied frequency is increased. The frequency-range necessary for the acceleration period of 1 sec. is 330 kc./s. to 9·3 Mc./s., and during this time the protons make about 5×10^5 revolutions in or near the mean stable orbit. The necessary radio-frequency voltage on the accelerating electrode is achieved over a 30/1 frequency range by roughly tuning the 'cee' capacitance. This is done by a mechanically variable inductance driven in accordance with the known frequency-time variation. The form of the frequency-time law was found from precise measurements of the rate of rise of magnetic field which has been found satisfactorily reproducible. The radio-frequency is generated as a beat between a fixed oscillator and a variable oscillator the frequency of which is governed by a mechanically driven condenser shaped to provide the correct time-variation. Further details of the whole equipment were given in an earlier article[4].

In preliminary tests of the synchrotron, beams of particles were observed to strike current collection and scintillation probes inserted at various points in the vacuum tube. For testing over the full range of energy, a convenient form of beam indication is the signal induced on an insulated plate at the bottom of the vacuum system by the bunched beam circulating near the median plane. From the size of this signal, it is estimated that the fully accelerated pulses contain about 10^8 protons. At the conclusion of the acceleration, the beam may be made to move either to the inside or to the outside wall of the vacuum tube; provision is being made for the insertion of suitable targets. Scattered protons have been observed outside the vacuum system, and tracks of π-mesons have been seen in nuclear emulsions exposed near by.

In the present early stages of operation of the synchrotron, effort is concentrated mainly on improving the performance and on measuring radiation

levels. This is necessary for the proper design of shielding which will protect those working near the machine and also allow access to the various beams of radiation from targets. A detailed experimental programme is being prepared, and it is hoped that this synchrotron, which provides π-mesons of energies up to at least 700 MeV., will add significantly to existing information on the nuclear interactions of high-energy particles. It is clear that the accumulation of events of interest in nuclear emulsions and cloud chambers is likely to be rapid.

[1] *Rev. Sci. Instr.* (the September 1953 issue is devoted to a description of the Brookhaven cosmotron).
[2] Oliphant, M. L., Gooden, J. S., and Hide, G. S., *Proc. Phys. Soc.*, **59**, 666 (1947).
[3] *Nature*, **169**, 476 (1952).
[4] Hibbard, L. U., *Nucleonics*, **7**, No. 4, 30 (1950); see also *The Engineer*, **195**, 271 and 305 (1953).

OBITUARIES

Prof. A. F. Holleman

Arnold Frederik Holleman died on August 11, and so passed the doyen of Dutch chemists and one who held a special place in the hearts of his countrymen, not only for what he had done for the cause of science, and of organic chemistry in particular, in Holland, but also as one of the band of famous scientists who succeeded in bringing the universities of Holland into the very forefront of scientific progress.

During his long life of almost ninety-four years, Holleman formed a connecting link between the earlier period of organic chemistry and modern developments. He was born at Oisterwijk in North Brabant on August 28, 1859, and received his early chemical education from Dr. Lamers, a pupil of Kekulé. He proceeded in 1879 to Leyden, where he studied under the two famous teachers, Franchimont and van Bemmelen, and also had instruction from van Romburgh, Bakhuis Roozeboom and Lobry de Bruyn. Then followed a period under Bunsen at Heidelberg and one in von Baeyer's laboratory at Munich, where he was contemporary with Bamberger, Claisen, Nef and Friedlander. In 1887 he returned to Holland to work with van't Hoff at Amsterdam, where he also met Eijkman. Here he started his career as a teacher; he became professor at Groningen in 1893, and a little later he succeeded Lobry de Bruyn at Amsterdam, where he remained until he retired in 1924 at the age of sixty-five.

The effect of Holleman's lifelong friendship with van't Hoff and his contacts with Eijkman and Bakhuis Roozeboom is to be seen in the direction his researches took at Groningen and Amsterdam. As a student of the Leyden school, he was interested in the chemistry of substitution in aromatic compounds, and his thesis for his doctorate (1887) dealt with "Researches on the so-called β-Nitro-cymene"; his fame, however, rests on the application of exact physico-chemical methods to the quantitative study of the problem. His researches enabled him in 1910 to publish his famous book "Die Einführung von Substituenten in den Benzolkern", truly the basis on which the English school later built the electronic theory. He was still stressing the importance of the quantitative aspect of the subject in probably the last of his papers, published in 1947.

After his retirement, Holleman lived in Bloemendaal, but still devoted himself to science, as secretary to the Hollandsche Maatschappij der Wetenschappen, Haarlem, and on various committees of the Dutch Chemical Society, which obtained its Royal title a few days before his death, and in which he was particularly interested.

No notice would be complete without reference to Holleman's fame as a teacher. Anyone who studied organic chemistry at a Dutch university could 'feel' it, and it was also a reason for the success of his text-book, which passed through sixteen editions between 1896 and 1951 (he supervised the whole of the manuscript of a recent English translation) and was translated into many languages. S. Coffey

We regret to announce the following deaths:

Mr. R. H. Burne, F.R.S., sometime physiological curator of the Hunterian Museum, Royal College of Surgeons, on October 9, aged eighty-five.

Mr. James Fairgrieve, formerly reader in education with special reference to geography in the Institute of Education, University of London, on October 8, aged eighty-three.

NEWS and VIEWS

Aerodynamics at the National Physical Laboratory: Mr. A. Fage, C.B.E., F.R.S.

Mr. A. Fage, who retired from the post of superintendent of the Aerodynamics Division of the National Physical Laboratory last summer, is one of the pioneers of aeronautical research. He went to the Laboratory in 1912, after an education at the Portsmouth Dockyard Schools and the Royal College of Science, London, and joined the small group of workers who were beginning to establish an aeronautical section at the Laboratory under the guidance of the then Dr. Stanton and Mr. Bairstow. His early work ranged over the whole field of aerodynamics as it then existed; but he made a special study of the characteristics of airscrews and laid the foundations of airscrew theory. He wrote two books at this time, on airscrews and on the aeroplane, as a guide to designers. About 1920, Mr. Fage began to study the problems of the boundary layer and of turbulent airflow which have been his main work and have brought him international fame and the fellowship of the Royal Society (1942). He was the first to measure, by the use of Stanton's surface Pitot tube, the distribution of skin friction along the chord of an aerofoil, and to show in detail the nature of the transition from laminar to turbulent flow. His work on the effects of surface imperfections on skin friction did much to emphasize the great importance of smooth and accurately shaped surfaces for the attainment of the lowest possible drag.

Mr. Fage was a brilliant experimentalist but had a sufficient knowledge of the underlying theory to enable him to interpret lucidly the results of his experiments. Many of his experimental researches show an almost uncanny skill, and also a great degree of patience, in attacking new and difficult problems. Incidentally, he made some of the first experiments on laminar flow aerofoils. He was appointed superintendent of the Aerodynamics Division at Teddington in 1946 and since then has devoted much of his time

to the improvement and modernization of the equipment of the Division, particularly the planning of the great extension of high-speed researches now in progress. His work will long be remembered and honoured, especially in the field of experimental research on fluid motion, of which he was a master. He was awarded the C.B.E. in the Coronation honours as a recognition of his great contributions to aeronautical knowledge.

Dr. W. P. Jones

Dr. W. P. Jones, who has succeeded Mr. Fage, went to the National Physical Laboratory in 1933, having taken degrees in both mathematics and physics. His mathematical ability led to his being attached to the group of scientists under Dr. R. A. Frazer who were engaged on flutter research, and he has made this subject his chief work at the Laboratory ever since. In particular, he has studied profoundly the theory of aerodynamic forces on bodies in unsteady motion, and is an acknowledged world authority on this subject. His work on the aerodynamic derivatives of oscillating aerofoils has provided an invaluable basis for the solution of flutter problems, and his methods are widely used by aircraft designers. Having established a satisfactory theory for low speeds, he proceeded to study the effects of compressibility of the air, and so extended his theory into the transonic and supersonic ranges of flight. His findings have been compared with experimental measurements whenever possible, with good results, and it can be said that as a result of his work we now possess a very substantial foundation of knowledge of flutter derivatives, except in the narrow range of speeds close to that of sound.

Dr. Jones has, from time to time, devoted his attention to other problems, usually related to fluid motion, and has written a large number of papers for the Aeronautical Research Council and its committees, many of which are published in the Reports and Memoranda of the Council. His interests outside aeronautics are gardening and shooting, for which latter recreation he likes to go to his native Wales. As superintendent of the Aerodynamics Division at Teddington he will naturally have less time for individual research; but it is to be hoped that he will find some opportunity of extending his work on unsteady fluid motion, and particularly of studying further the difficult but important question of flutter in the transonic speed-range.

Recruitment of Higher Personnel for the British Textile Industry

In his address to the autumn convocation of the Textile Institute, Manchester, on October 2, Sir E. Raymond Streat, chairman of the Cotton Board, Manchester, and former president of the Institute, stressed the need for the British textile industry to employ more highly trained staff, not only technologists but also men expert in management and its various techniques and who possess character and energy. He thought that there is much to be said for the practice of employing at least one person whose duties might not be rigidly defined but who has the ability and training to fill a sudden vacancy among the senior staff or who could examine a technical or managerial problem. Industry needs to attract more of the best brains in the country which have traditionally entered the professions or the Civil Service; it can no longer rely entirely on traditional methods of recruitment. A definite policy of staff recruitment and promotion is required, and this must take account of the fact that the widening of educational opportunities, with the consequence that more and more of the ablest boys enter the grammar schools and then the technical colleges and universities, greatly diminishes the possibilities of finding the requisite ability for promotion on the shop floor. To attract more of the best material into industry it is not sufficient to make the needs of the textile industry known. Within the industry, and within individual firms, an organization should be created for the reception and training of staff, and this should include provision for training in the techniques of management. Sir Raymond ended by saying that the textile industry is probably a little too cautious in giving its young men responsibility, and experience could only come through responsibility.

Irregularities in the Period of Rotation of the Earth

An examination of all the possible factors contributing to variations in the earth's rotation period has been made by Walter Munk and Roger Revelle and published by them in a paper entitled "On the Geophysical Interpretation of Irregularities in the Rotation of the Earth" (*Mon. Not. Roy. Astro. Soc., Geophys. Supp.*, **6**, 6; Sept. 1952). It is shown that the seasonal variation in the distribution of air mass has a very small effect and that alterations in the sea-level cannot account for the major variations in the length of the day, although the effect is not necessarily negligible. If random fluctuations in the elevation of continental blocks of the earth's crust were sufficiently large to cause observed changes in the length of the day, they would also cause displacements in the pole of rotation much greater than those observed from 1890 to 1950. The evidence from tide gauges suggests that oscillations in the elevation of crustal blocks have been less than ten per cent of the amount required to account for the observed fluctuations in the length of the day. It is suggested that electromagnetic coupling of the mantle to a turbulent core could account for the observed fluctuations if the conductivity of the mantle is about 10^{-9} e.m.u. A numerical relationship has been derived between the fluctuations in the length of the day—as measured from observatories anchored to the mantle—and the variations in the westward drift of the earth's magnetic field, and this indicates that these fluctuations can be explained by a variable motion in the core amounting to a fraction of the total motion.

Science and the Arts

In an article comparing the relative merits of the arts and sciences, Prof. R. E. Gibson, professor of chemistry and director of the Applied Research Laboratory at the Johns Hopkins University, traces the development of applied research as it has evolved from natural philosophy and suggests that pure research is in danger of being smothered by its aggressive and powerful offspring (*Amer. Sci.*, **41**, No. 3; July 1953). Gibson believes that modern science reflects the dual nature of man and that both the useful and liberal arts are manifestations of the passion for truth that underlies civilization. In the same journal the ultimate disposal of radioactive wastes is discussed by Mr. L. P. Hatch, who describes the use of montmorillonite clay as a method of packaging radioactive waste which is now being investigated at the Brookhaven National Laboratory.

Other articles include one by Dr. Shields Warren on the contribution of atomic energy to health.

"The Changing Flora of Britain"

Under the above title, and under the general editorship of J. E. Lousley, the papers read at the third conference arranged by the Botanical Society of the British Isles in 1952 have now been made available in book form (obtainable from the Society, c/o Department of Botany, The University, Oxford; price 15*s.*). This unusually full and interesting conference has already been noticed at some length in *Nature* (**169**, 1076; 1952). Readers of the book will find that it contains much original information and thought on floristic topics by distinguished exponents. The several essays, some twenty-four in all, deal with the central theme in its many aspects, the evidence being drawn from ecology, palæobotany, phytogeography and relating to such topics as the introduction and spread of aliens, special studies of trees and shrubs, etc. The wide casting of the net is perhaps indicated by the inclusion of such papers as those on "A Zoologist's Approach to a Changing Flora", "The North American and Lusitanian Elements in the Flora of the British Isles", and "The Conservation of British Vegetation and Species". This conference, together with the valuable text that has emerged from it, should do much to stimulate new interest in British field botany.

Wall Structure in *Valonia*

In an investigation of the cell-walls of species of *Valonia* and *Dictyosphaeria*, using the electron microscope, a general similarity of structure and development has been demonstrated (F. C. Steward and K. Mühlethaler, *Ann. Bot.*, N.S., **17**, 66, 296; 1953). The first cellulose laid down at a new surface, as on aplanospores, consists of a tangle of randomly arranged fibrils, these being embedded in a pectin-like amorphous material. As this first cellulose layer is either unable to grow enough by plastic flow or to stretch elastically, it is eventually torn and a new layer is formed within. At first the strands of the new layers are not exactly parallel, but they eventually acquire a high degree of regularity. In successive lamellæ the fibril direction shifts abruptly, apparently through an angle of 120°, that is, the direction is repeated every fourth layer. The bearing of these observations on the interpretation of the growth of the cell wall is considered.

International Institute of Refrigeration

Commissions I and II of the International Institute of Refrigeration held a joint meeting at Zurich during September 10–12. The main topics of discussion were: (1) liquefaction, distillation, rectification and adsorption; (2) properties of materials used at low temperatures. Prof. P. Grassmann was in charge of the local arrangements, which included visits to the laboratories of the University and to heat pump installations. A survey of the field of work of Commission I was given by Prof. F. E. Simon (Oxford) and that of Commission II by Dr. Ezer Griffiths (National Physical Laboratory, Teddington). The contributions on gas liquefaction, etc., included papers on liquid vapour equilibrium of the system argon–oxygen and the manufacture and use of tonnage oxygen. On the engineering side, apparatus for the liquefaction of air, hydrogen and helium was discussed. A group of papers was submitted on properties of materials: one dealing with the effect of low temperatures on the engineering properties of metals, another on the metallurgy of iron and steel at − 196° C., and a paper on the strength of aluminium crystals at low temperatures. Another group covered thermal conductivities of metals, moist cork, and porous materials under reduced pressures. Altogether nineteen papers were read and discussed. A bulletin containing the papers and discussions will be published by the Institut International du Froid, 177 Boulevard Malesherbes, Paris 17e.

Zoological Society of London: Special Courses

The Zoological Society of London, at the request of the Colonial Office, arranged a study-leave course during the month of September for selected members of the Colonial Service in Africa; those attending came from game, veterinary and forestry departments. The course was designed to help the members of those services who wish to do some serious work on the African fauna, particularly the mammals, but need some assistance and guidance in setting their steps in the right direction. The course consisted of lectures, demonstrations and practical work; it included instruction on elementary anatomy and physiology, reproductive cycles, parasites, classification, ecology and the techniques of field-work. Prof. E. C. Amoroso (Royal Veterinary College) and Mr. R. W. Hayman (British Museum (Natural History)) collaborated with the Society's staff: it is hoped that similar courses will be arranged in future years.

A course for school teachers has been provided, in conjunction with the L.C.C. Education Department, on "Animals at the Zoological Gardens". Lectures are given on Saturday mornings during October and November; after each lecture the class divides into small parties that are conducted by the lecturers around special sections of the menagerie for demonstration and further informal instruction. The course is designed as an aid to teachers who bring parties of children on educational visits to the Zoological Gardens, so that they may organize their work to the greatest possible advantage. Prof. H. R. Hewer, assisted by Dr. K. A. Kermack and Dr. D. M. Ross, is conducting the course. The Society is arranging its usual lectures for children of Fellows during the Christmas holidays.

Fifth Canadian High Polymer Forum, London, Ontario

The fifth Canadian High Polymer Forum will be held in the auditorium of the London Public Library and Museum, Queen's Avenue, London, Ontario, during November 19–20. Seventeen papers have been arranged, and further contributions can still be accepted for the final programme by submitting a title and an abstract of two hundred words to the programme chairman, Prof. R. V. V. Nicholls, McGill University, Montreal, Quebec. Besides visits to the University of Western Ontario and to local industries, there will be a special dinner at which Dr. D. P. Riley, of the Royal Institution, London, England, will give an address. Hotel reservations and further information can be obtained from the secretary-treasurer of the Forum, Dr. H. Leverne Williams, Polymer Corporation, Ltd., Sarnia, Ontario.

Nature Conservancy: Awards

The Nature Conservancy has made the following awards of research studentships for postgraduate training in ecology, tenable for periods of up to three years at the universities shown: *Botany*, Miss J. C.

Brown and G. W. F. Sewell (Royal Holloway College, London); *Zoology*, J. K. Bates (Jesus College, Oxford), P. F. Entwistle (Imperial College of Science and Technology, London), T. Huxley (Balliol College, Oxford), C. J. Duncan and E. J. Perkins (Queen Mary College, London), P. E. S. Whalley (University College of North Wales, Bangor), J. Godfrey (University of Edinburgh) and Miss L. M. C. McCartan (St. Hugh's College, Oxford); *Physiography*, C. Embleton (St. John's College, Cambridge) and W. A. Westgate (University of Durham).

Illuminating Engineering Society: Awards

THE Illuminating Engineering Society has announced the following awards in connexion with papers presented to the Society during the past year: *Leon Gaster Memorial Premium*, to W. D. Chesterman (Royal Naval Scientific Service) and J. B. Collins (now at the Building Research Station, Garston) for their joint paper on problems of underwater illumination; *Silver Jubilee Commemoration Award*, to J. R. Wakefield (University of Nottingham) for his paper on an investigation of glare in mine lighting, and in view of the number and standard of entries submitted this year, a second award to Miss P. M. Excell (Research Laboratories, British Thomson-Houston Co., Ltd.) for a paper on illuminating calculations for installations using long linear light sources.

University of Birmingham: Appointments

PROF. A. J. MURPHY, professor of industrial metallurgy in the University of Birmingham, has been appointed director of the Combined Departments of Metallurgy in succession to the late Prof. D. Hanson. The title of University Research Fellow has been conferred upon the following during the tenure of their present posts: *Physics*, Dr. F. Aughtie (Department of Scientific and Industrial Research); *Electron Physics*, Dr. G. F. Alfrey (Admiralty contract). A. J. Williams has been appointed a Research Fellow in the Department of Metallurgy.

University College of North Staffordshire

DR. F. W. COPE, reader and head of the Department of Geology, University College of North Staffordshire, has been appointed professor of geology. The Polymer Corporation, Ltd., Sarnia, Ontario, has founded a research studentship in chemistry in the College for the support of postgraduate research on cationic polymerization under the direction of Dr. P. H. Plesch. The Blythe Colour Works, Ltd., Cresswell, North Staffordshire, has founded a fellowship in chemistry for the support of fundamental investigations into inorganic colouring matters; the first holder of the fellowship is Dr. S. C. Nyburg, assistant lecturer in the Department of Chemistry.

British Society of Rheology: Officers

AT the annual general meeting of the British Society of Rheology, held at the Imperial College of Science and Technology, London, on September 25, the following officers were elected: *President*, Dr. L. R. G. Treloar; *Honorary Secretary*, Dr. P. Feltham (Flat *H*12, Sloane Avenue Mansions, London, S.W.3); *Honorary Treasurer*, Mr. N. Wookey; *Honorary Editor*, Mr. A. A. Milne; *Northern Representative*, Mr. L. Grunberg; *Midland Representative*, Mr. A. W. Richardson; *Ordinary Members of Committee*, Mr. E. B. Atkinson, Mr. D. W. Jopling, Dr. E. W. J. Mardles and Mr. W. F. O. Pollett.

British Occupational Hygiene Society: Conference in London

THE first conference of the British Occupational Hygiene Society will be held in the London School of Hygiene and Tropical Medicine, Keppel Street, London, W.C.1, on November 2, starting at 11 a.m. The conference, which is open to those who are not members of the Society on payment of a fee of 10*s*. 6*d*. (covering tea and a copy of the report), is designed to provide a common forum for the many professions, medical and non-medical, concerned with occupational hygiene. Sir Walter Monckton, Minister of Labour, will open the proceedings, and will be followed by the president of the Society, Dr. Thomas Bedford (director of the Environmental Hygiene Research Unit, Medical Research Council), who will give an address. The rest of the programme will consist of three papers, as follows: measuring the worker's environment, by S. A. Roach (dust physicist, Pneumoconiosis Research Unit, Medical Research Council); problems of chemical toxicity, by Dr. D. G. Harvey (head of the laboratories, Department for Research in Industrial Medicine, Medical Research Council); and occupational hygiene and the industrial designer, by J. E. Braham (engineering controller, Imperial Chemical Industries, Ltd.). Those who intend to be present at the conference should notify before October 15 the honorary secretary of the Society, Peter C. G. Isaac, Public Health Engineering Laboratory, King's College, Newcastle upon Tyne, from whom further particulars can be obtained.

Announcements

THE Eddington Lecture will be given this year in Cambridge at the Arts' School, Bene't Street, Cambridge, on November 3 at 5.30 p.m. by Prof. H. H. Price, Wykeham professor of logic in the University of Oxford. The title of Prof. Price's lecture will be: "Some Aspects of the Conflict between Science and Religion".

THE Leopold von Buch Medal of the German Geological Society has been awarded to Dr. W. J. Arkell, senior Research Fellow of Trinity College, Cambridge, particularly for his researches on the British Jurassic which have greatly stimulated work on the problems of Jurassic stratigraphy all over the world.

DR. LAURENCE MCKINLEY GOULD, president of Carleton College, Northfield, Minnesota, who is well known as a geologist and geographer, has been appointed to the board of the United States National Science Foundation in succession to Dr. J. B. Conant, who has resigned on becoming the United States High Commissioner for Germany.

THE Chemische Gesellschaft in der Deutschen Demokratischen Republik was founded in Berlin on May 11. The officers are: Prof. E. Thilo (*president*); Dipl.-Ing. Kaiser (*secretary*); Prof. H. Bertsch (Berlin); Prof. H. Franck (Berlin); Dr. Heyder (Bitterfeld); Dr. W. Schirmer (Leuna); Prof. A. Simon (Dresden); Prof. W. Treibs (Leipzig).

THE Institute of Rural Life at Home and Overseas will hold its annual conference at High Leigh, Hoddesdon, Herts, during January 4–8 under the chairmanship of Sir John V. W. Shaw, formerly governor and commander-in-chief of Trinidad and Tobago. The conference will consist mainly of a number of lectures and discussion-group sessions. Further details can be obtained from the Secretary of the Institute at 84 Eccleston Square, London, S.W.1.

CHEMISTRY OF PLANT GROWTH SUBSTANCES

CHEMICAL structure in relation to plant growth-regulating activity was discussed at a symposium held in Sweden in the Botanical Department of the University of Lund during August 10–14. The meeting was arranged by Prof. H. Burström (Lund), Dr. H. Veldstra (Amsterdam) and Prof. R. L. Wain (London), and participation was restricted to active workers in this field. Some forty chemists and biologists from eight countries were present.

Dr. Veldstra, who introduced the first session on "Structure and Activity", gave a review of published work in this field and an account of his own recent investigations. In particular, he showed that compounds like 1-naphthylmethanesulphonic and 1-naphthalenesulphonic acids can show growth-regulating activity at higher concentrations (10^{-2}–10^{-3} *M*). In view of the high dissociation constants of these acids, it would appear that the anion is active in promoting the growth response. Dr. C. Hansch (Claremont, U.S.A.) discussed the evidence for the reaction of a growth substance with a plant substrate. His suggestions that, within the plant, a nuclear chlorine atom can be removed from certain chlorinated benzoic acids and that a methyl group might be eliminated, for example, from the growth substance 3-chloro-2 : 6-dimethylbenzoic acid, promoted a lively discussion. In assessing growth-regulating activity Dr. Hansch rates a compound as active if it promotes a 5 per cent increase in growth above the controls in the *Avena* cylinder test. This method of assessment was criticized as one in which synergism may play an important part. In the last paper of this session, Prof. H. Söding (Hamburg) discussed the chemical nature of the growth substance in *Avena* coleoptiles. In recent years Prof. Söding has made a survey of the data relating to the possible existence of auxins *a* and *b*, and a re-analysis of the evidence relating to acid and alkali stability and rates of diffusion has led him to conclude that, so far, indole compounds are the only auxins which have been established as occurring naturally within the plant.

The second session was devoted to papers on optical isomerism in relation to growth-regulating activity. Dr. H. Matell (Uppsala) described how he has determined configurations in a series of optically active aryloxyalkylcarboxylic acids by constructing melting-point curves. When the optical isomers of similar aryloxy acids are studied in this way, the curves reveal the formation of quasi-racemates when the two isomers differ in configuration. Dr. B. Åberg (Uppsala) followed with a paper on the physiological effects of these compounds. His results were in agreement with the idea that activity involves the association of the compound with some enzyme system, certain groupings in the molecule becoming associated with specific receptor groups on the enzyme surface. His work is closely in line with that of Prof. Wain, Prof. Burström and others, and in discussion it was evident that much work on anti-auxins and auxin antagonists is now proceeding. This field of investigation was considered further in the third session. Prof. L. J. Audus (London) gave a critical evaluation of the present concepts of auxin antagonists. He made a plea for rigid standardization in the preparation of biological materials and in experimental method, stressing the importance of proper statistical analysis of results. Dr. H. Erdtman (Stockholm) discussed some approaches to the study of anti-auxins, and Dr. C. Mentzer (Lyons) described his investigations on the antagonistic effects of *N*-methyl-*N*-phenylglycine and *N*-methyl-*N*-acetonyl-aniline on the growth of carrot in tissue culture experiments *in vitro*.

The fourth session, on the mode of action of growth substances, was opened by Prof. R. L. Wain (London), who discussed the breakdown of certain ω-aryl- and ω-aryloxy-alkylcarboxylic acids in plants. Chemical evidence was presented which indicates that, within the flax plant, phenoxy acids may be degraded by a β-oxidation mechanism and that with certain chain-lengths ω-oxidation might also occur. These findings were considered in relation to the results obtained by other workers in human and animal metabolism studies. Prof. Wain also indicated the steric considerations which led Toothill to prepare and test the growth-regulating activity of 2 : 4-dichloro-6-fluoro- and 2 : 4-dibromo-6-fluoro-phenoxyacetic acids. The high activity found with these compounds was shown to stand in marked contrast to the inactivity of the corresponding 2 : 4 : 6-trichloro- and 2 : 4 : 6-tribromo-acids. Certain physico-chemical aspects of plant growth-regulating activity were dealt with by Dr. R. C. Brian (Bracknell, Berks), who gave a paper on the interaction of growth substances with monolayers of proteins, lipids and material produced directly from plant tissues. Evidence was presented showing that 2-methyl-4-chlorophenoxyacetic acid is almost completely ionized at the *p*H occurring within plant cells, where it must therefore exist as the anion. The increase in physiological activity which is observed at lowered *p*H was attributed to ionization changes in the protein complexes within the plant affecting their interaction with the growth-substance anion. Material obtained from the tissues of different plant species was shown to vary greatly in capacity to adsorb the growth substance; but no general correlation between this capacity and susceptibility of the plant to the herbicidal action of the chemical could be drawn. Drs. H. Linser and K. Kaindl (Linz, Austria) discussed the concentration/activity curves of various growth activators and growth inhibitors in the "*Avena*-Pastentest" and the interpretation of the results. Dr. H. L. Booij (Leyden), in a theoretical contribution on mode of action, directed attention to the similarity between the action of plant growth substances and those of haptens in serological reactions. He pointed out that, in general, both types of compound are water-soluble, have low molecular weights and they may operate as anions. It was suggested that certain enzymes bound to protein within the resting plant cell might be liberated under the action of a growth substance in a manner analogous to that in which a hapten, by associating with a specific antibody, affects the normal antigen–antibody relationship.

The final session, dealing with physiological aspects, was opened by Prof. K. V. Thimann (Harvard), who described work with certain compounds which might arise from the oxidation of 3-indolylacetic acid. The inactivity of these substances has led him to consider it unlikely that an oxidation mechanism is

involved in the growth-regulating activity of this acid. In his studies on anti-auxins, Prof. Thimann has found that, under certain conditions, 3-methylindole can depress the activity of 3-indolylacetic acid. The effect is not shown with low concentrations of the acid, indicating that competitive antagonism is not involved and that 3-methylindole is not an anti-auxin. Prof. Thimann has concluded from further experiments that 2 : 4-dichloroanisole, claimed to be an anti-auxin by Bonner, is likewise a growth inhibitor only. Studies with 3-indolylacetonitrile were also described by Prof. Thimann. Evidence was presented which indicates that, in tests where the nitrile shows activity, such activity depends upon its conversion to 3-indolylacetic acid within the plant tissue. Prof. H. Burström (Lund), in a comprehensive physiological paper, made an attempt to define growth activity. In particular, he dealt with auxin and anti-auxin activity, the type of antagonism shown only by external growth substances, the disturbance of geotropic responses, and toxicity. The paper, which was illustrated throughout by detailed reference to the growth effects obtained with specific compounds, focused attention on the complex interplay of physiological processes which may be concerned in promoting the various types of growth response.

R. L. Wain

CHEMICAL PROCESSES AND CHEMICAL ENGINEERING TECHNIQUES

THE first chemical plant exhibition to be held in Great Britain since 1936 was housed at Olympia, London, during September 3–17 in conjunction with the annual engineering, marine and welding exhibitions. The Institution of Chemical Engineers, together with the Chemical Engineering Group of the Society of Chemical Industry, marked the occasion by holding a chemical engineering conference during the five days commencing September 7.

The meetings were avowedly general in nature, being designed to support the plant exhibition, and the theme of the entire conference could be described as one of 'materials and methods'. Perhaps the focal point of the meetings was that held under the chairmanship of Mr. Stanley Robson, at which the implications of recent reports upon American practice ("Chemical Apparatus in the U.S.A." by the Organization for European Economic Co-operation, and "Heavy Chemicals" by the Anglo-American Council on Productivity) were considered.

Sir Harold Hartley and Mr. J. Grange Moore initiated a wide discussion in which the most pre-eminent views were that industry needs more chemical engineers, but should also make better use of those it has. Prof. M. B. Donald warned the profession that it would find itself starved of entrants unless something were done to reduce the serious shortage of science teachers in grammar schools.

Around this central theme, covering the whole scope of chemical engineering, other papers were placed dealing with more specific developments in processes and techniques. Among these were contributions dealing with some unusual materials of construction. Thus, carbon and graphite (Mr. A. W. Morrison), tantalum and zirconium (Dr. G. L. Miller) and plastic materials (Mr. Verney Evans) were presented, and their special properties and applications in the chemical industries illustrated. Much interest was shown in these topics; and the importance of constructional materials, in that their development is often the limiting factor in the application of new processes, was stressed by more than one speaker.

The remaining papers presented to the conference dealt with chemical processes and chemical engineering techniques. Two interesting examples of specialist design and operation resulting from the penetration of chemical engineering fundamentals into two specific processes were provided by papers on milk processing plant (Mr. J. E. F. Renton) and formaldehyde production (Mr. K. Nickels).

The increasing use of chlorine throughout the industry made of timely interest a paper on developments in the production of chlorine in mercury cells (Mr. L. R. Thomas), particularly as the author drew many useful comparisons between alternative cell designs. A paper on advances in evaporation, with particular reference to the concentration of heat-sensitive liquids (Mr. B. N. Reavell), provided further examples of the application of a general technique to a specific problem. This provoked a lively discussion by its treatment of the economics of multiple-effect evaporation, as well as by a description of lesser-known systems, such as low-temperature climbing-film machines operating on the heat-pump principle.

Of more general interest was a review of developments in distillation since 1940 (Mr. G. A. Dummett). Although necessarily very compressed, the paper made an assessment of the important progress which has been made during the past thirteen years in fundamental physical data, in theoretical design methods and in practical industrial equipment.

In ranging from the very general comparison of the practice of chemical engineering in Great Britain and the United States to the wide distribution of a particular operation, this brief report discusses in a re-arranged order the papers of the conference and not in the order in which they were read.

T. K. Ross

BRITISH PHARMACEUTICAL CONFERENCE, 1953

THE ninetieth British Pharmaceutical Conference was opened at Grosvenor House, London, on August 31, and more than six hundred pharmacists attended. The range of topics covered in the scientific sessions illustrates the extensive development of pharmaceutical research.

Fresh interests in the constituents of plants were demonstrated by several workers who have applied new methods of analysis. The quantitative estimation of the ergot alkaloids has been achieved by partition chromatography on cellulose columns, and colorimetric assay of the fractions shows that recoveries of pure individual alkaloids are consistent. The constituents of digitalis tinctures have been investigated, no correlation having been found between the potency of frogs to the glycosides and the intensity of the colour reaction. Other workers have applied paper-partition chromatography to the separation of the tropane alkaloids, their estimations being carried out by use of the Vitali–Morin reaction. The chromatographic method has been particularly useful in estimating the hyoscine and hyoscyamine content of *Datura sanguinea*.

From experimental work on the biogenesis of the tropane alkaloids some speculations have been made, and the results appear to indicate that the product of synthesis is related to the site of synthesis. The histochemical evidence for alkaloid production in meristematic tissues has been corroborated, and two other workers directed attention towards the root as the locus of alkaloid synthesis. Reciprocal grafts between tetraploid and diploid *Datura stramonium* have been made, and it was suggested that the genetical nature of the stock determines the alkaloidal content of scion and stock. In branch chimæras the tetraploid branch is richer in alkaloid than the diploid branch growing on the same root.

One curious fact has come to light as a result of a study of the anthraquinone glycosides of cascara, namely, that galenical preparations containing glycosides in amounts similar to those found in the crude drug are only half as active. The use of boiling water and autoclaving was stated to be a more efficient method of producing the dry extract of cascara than extraction with cold water; apparently, evaporation of the percolate under reduced pressure does not enhance the potency of the final product.

The use of dihydrostreptomycin and of penicillin as a mixed preparation raises an assay problem, and it has been established that the success of any microbiological method must depend on the absence of interference by dihydrostreptomycin. A further paper related to the origin of stimulation zones on penicillin assay plates, and attributed the cause, in part, to additional nutrients having diffused from the inhibition zones.

A method was described using small groups of guinea pigs for demonstrating the prolonged action of globin insulin and protamine zinc insulin. The guinea pig was recommended as a satisfactory test animal, whereas this demonstration cannot be carried out with the rabbit. Another paper compared the efficiency of two official pyrogen tests, and suggested that the further use of rabbits, which had once been used in a test in which pyrogen had been found, should be forbidden. The maximum degree of restraint which may be imposed on the rabbits should be specified and electrical thermometers should be used.

The work of several contributors was focused on the stability of some pharmaceutical preparations. Methods of assessing the chemical stability of procaine benzyl-penicillin in aqueous media were described. A study of different batches of vitamin B_{12} injections has shown that differences in potency are caused by exposure to daylight. Although copper is known to affect the stability of aneurine hydrochloride solution, it was pointed out that the same effect is greatly diminished in dry powders when stored at room temperature over long periods. The problem of assessing emulsion stability was considered, and the breakdown has been investigated over the temperature range 4–85° C. It is considered that globule-size frequency analysis yields a reliable picture of the internal state of the emulsion. Elevated temperature was proposed as an artificial breakdown stress for the evaluation of emulsion stability.

Pharmacological research on some synthetic drugs was reported, and one substance has proved of value as a substitute for *p*-amino-salicylic acid, appearing to delay the emergence of streptomycin resistance. A structural analogue of hydrocortisone has been prepared and found to inhibit the glyconeo-genetic activity of cortisone acetate in adrenalectomized rats.

Further research has been carried out on bacterial survival in systems of low moisture content, and oils suitable for use in 'sterility tests' have been ingeniously prepared. A limiting viable count technique has been modified. Also reported was the fact that, by using soluble surface-active agents in small amounts, cotton dressings will retain their absorbency better than the conventional type. Three papers read at the Conference made a useful contribution to the problem of evaluating antacids, and a further paper described a rapid method of determining calcium and magnesium by titration.

For many years pharmacists have been 'glass conscious' and aware of the necessity of controlling its quality and characteristics when used as containers for pharmaceutical preparations. With the latter comment one paper was introduced as a contribution to the symposium session, which dealt with the pharmaceutical aspects of glass and rubber. Experiences with containers and closures in the pharmaceutical industry were also discussed.

S. B. Challen

MOVEMENT OF POSTGRADUATE SCIENCE STUDENTS

Among the activities of the British Council which are of direct interest to science none is more important than its encouragement of the movement of scientists, by bringing to Great Britain scientists, both postgraduates for purposes of advanced study or research, and more senior people to visit their opposite numbers, and by arranging for British scientists to pay lecturing or advisory visits overseas. This flow of scientists is, of course, only part of such movements, and because the funds available to the British Council for these purposes are limited, it is essential that they should be deployed in those directions where the need is greatest. This cannot be done effectively without a reasonably accurate knowledge of the flow of scientists promoted by other sources. Various publications indicate the awards available; but hitherto there have been no statistics showing the extent and characteristics of the flow which actually occurs.

For this reason the Executive Committee of the British Council in November 1951 agreed to the appointment of a working party of representatives of the Council itself, the Royal Society, the Department of Scientific and Industrial Research and the Medical and the Agricultural Research Councils, to review broadly and report on existing facilities for the movement of scientists, so as to arrive at a measure of the present scale of such activities, and to explore the need for any further co-ordination. The working party consisted of Sir Alfred Egerton, Dr. D. C. Martin, Dr. Alexander King, Mr. W. G. Alexander, Dr. F. H. K. Green (who withdrew later since in his opinion the examination was unlikely to yield data of use to medicine) and Sir Kenneth Loch, and it selected the calendar year 1951 as a sample period, deciding also to limit the investigation to the movement of graduate scientists whose journeys were made for the purpose of either advanced study or research. Assistance was sought from British universities, official bodies, trust funds and other organizations known to have an interest in this type of movement. For each individual information was collected on the professional status

Table 1. No. of Postgraduate Students entering Great Britain in 1951

	Physical sciences	Biological sciences	Bacteriology, biochemistry, pathology	Medicine	Engineering	Agriculture	Miscellaneous	Total
Commonwealth								
Australia, New Zealand	50	15	13	28	28	3	2	139
India, Pakistan, Ceylon	47	17	23	63	86	7	3	246
South Africa	10	2	6	18	20	2	—	58
Canada	37	8	—	23	18	1	—	87
Colonies	4	1	2	22	5	5	—	39
	148	43	44	154	157	18	5	569
Foreign								
Europe	76	13	19	92	44	16	5	265
Middle East	30	8	6	47	30	10	1	132
Far East	6	3	4	17	10	3	1	44
Latin America	4	2	4	41	7	7	1	66
U.S.A.	46	9	6	29	9	—	—	99
	162	35	39	226	100	36	8	606
Total	310	78	83	380	257	54	13	1,175

Table 2. No. of Postgraduate Students leaving Great Britain for Study abroad in 1951

	Physical sciences	Biological sciences	Bacteriology, biochemistry, pathology	Medicine	Engineering	Agriculture	Miscellaneous	Total
Commonwealth								
Australia, New Zealand	1	5	2	5	3	2	—	18
India, Pakistan, Ceylon	3	7	—	1	1	—	—	12
South Africa	2	—	—	—	—	—	—	2
Canada	18	4	4	14	14	1	—	55
Colonies	5	7	1	4	—	—	1	18
	29	23	7	24	18	3	1	105
Foreign								
Europe	51	18	12	41	20	23	—	165
Middle East	7	2	—	1	1	—	—	11
Far East	—	—	—	1	—	—	—	1
Africa (ex. Egypt, Sudan	11	3	—	1	—	—	—	15
Latin America	3	6	—	—	—	—	—	9
Arctic	5	1	—	—	—	—	—	6
U.S.A.	59	9	21	60	28	41	2	220
	136	39	33	104	49	64	2	427
Total	165	62	40	128	67	67	3	532

of the scientist, his subject, the broad purpose and duration of his visit, and the country concerned.

Thanks to the willing and helpful co-operation of those approached, information was collected and analysed on the movements of more than five hundred scientists from Britain and some eleven hundred visiting Britain. It is believed that the survey covers more than 80 per cent of the total movements of this type, and that it is thus sufficiently comprehensive to give a useful cross-section of the whole flow. The statistics thus obtained are summarized in a series of tables, of which those relating to the movements to Britain and from Britain in 1951 by groups of countries and groups of subjects and to the comparative flow of scientists are reproduced as Tables 1 and 2, respectively, herewith. Of scientists visiting Britain from Commonwealth countries, 30 per cent stayed for more than three and less than thirteen months, and 55 per cent more than thirteen and less than twenty-five months; for scientists coming from foreign countries, the corresponding figures are 36 and 26 per cent, respectively, while 22 per cent stayed for less than one month. Of scientists going from Britain to Commonwealth countries, on the other hand, 35 per cent stayed for more than one but less than three months, and 39 per cent for more than three and less than thirteen months; for those going to foreign countries the corresponding figures are 22 and 42 per cent, respectively, while 30 per cent stayed for less than one month. The British Council offers to place selected information at the disposal of other bodies interested in the movement of scientists; inquiries should be addressed to Administrator, Science Group, British Council, 65 Davies Street, London, W.1. It is also recommended that British Council representatives should be provided with the survey data relating to their country and those contiguous to it.

It is apparent from the survey that the saturation point of useful effort in the movement of scientists has not been reached. Thus in Latin American countries, where science is of recognized importance, comparatively little was being done; but in others, such as Egypt, the effort seems to be adequate. At home the effort is limited by the number of vacancies which could be made available at universities and technical colleges for postgraduate research workers or students from overseas. It is unlikely that offers from authorities abroad would in themselves be sufficiently attractive to British postgraduates for them to wish to work in those countries, and hence, owing to the advantages which would also accrue to Britain, provision should be made for any financial assistance required.

The working party found some difficulty in suggesting any practical way of analysing attendances at conferences. Although it is of opinion that Britain should be better represented at scientific conferences abroad, particularly in more distant countries, the effect of the recent Treasury relaxation of currency restrictions for British scientists attending conferences

in many countries could not be judged. In view of all the factors, the working party recommends that consideration of the question of greater facilities for the attendance of scientists at conferences should be deferred until the report of the Drogheda Committee is available.

SUPPLY AND EDUCATION OF MANAGERS FOR BRITISH INDUSTRY

A BOOKLET issued by the British Institute of Management contains the text of speeches delivered at the Second Scottish Conference held at Gleneagles during April 10–12. Among the subjects debated was that of finding the next generation of managers for British industry, and Dr. N. C. Hunt, referring to the figures supplied by Dr. E. Ashby, which indicate that industry will in future have to recruit its managerial staff from the universities because the reservoir of highly intelligent young people available outside the universities is drying up, discussed the kind of education and training which should be given to university students.

In his paper Dr. Hunt pointed out that, of hundreds of departments of business administration in the United States, only thirty are recognized by the Association of American Universities, and even if it does not matter what subjects are studied in developing the qualities desirable for administration, all subjects are not of equal value in giving the knowledge required. So long as normal university standards of teaching and research are maintained, Dr. Hunt thinks administrative studies could reasonably be included in a university curriculum. Postgraduate training might be given immediately after graduation or after some years of industrial experience; while the short courses offered at the Administrative Staff College, Henley-on-Thames, are extremely useful, they are not the whole answer, especially for the more junior executive who lacks the experience to profit from a course deriving its value from the interchange of experience rather than from formal study. There are already postgraduate courses in business administration at the Universities of London and Manchester and one is under consideration at Edinburgh, while there is a Department of Engineering Production at Birmingham. Dr. Hunt maintained that only in a university could be found the departments specializing in the basic disciplines out of which administration springs—economics, psychology, sociology, law and the applied sciences—and it is upon these that an advanced school of administration must be built.

In emphasizing that education for management must be a co-operative effort between the teaching institutions and industry, Dr. D. S. Anderson pointed out that in practice this means that industry must be willing to lend staff for lecturing in management courses; to accept trainees for long or short periods; and to take the trouble to arrange proper schemes of training as well as to supply frank particulars of successful and unsuccessful experiments and to second staff from time to time for further training. It also involves willingness on the part of academic staff to keep up to date by maintaining close contacts with industry, or even to return to industry for periods of 'refreshment', and that industry should be prepared to put some consulting work in the way of academic institutions because of the value which such work has in keeping a teaching staff in touch with actual practice. The content of courses does not present any serious problem; but it is essential that the various kinds of courses should not be limited to managers or potential managers, but should also provide for the training of workers' representatives. Dr. Anderson continued by saying that intelligent discussion—for example, in joint consultation—means intelligence on both sides of the table, and he thinks that only by education and training could one remove the feeling of inferiority to which lack of co-operation is so often due.

SUSCEPTIBILITY OF THE GUINEA PIG TO PHARMACOLOGICAL FACTORS FROM ITS OWN SERUM

By Drs. M. E. MACKAY*, A. A. MILES, C.B.E., M. SCHACHTER and D. L. WILHELM

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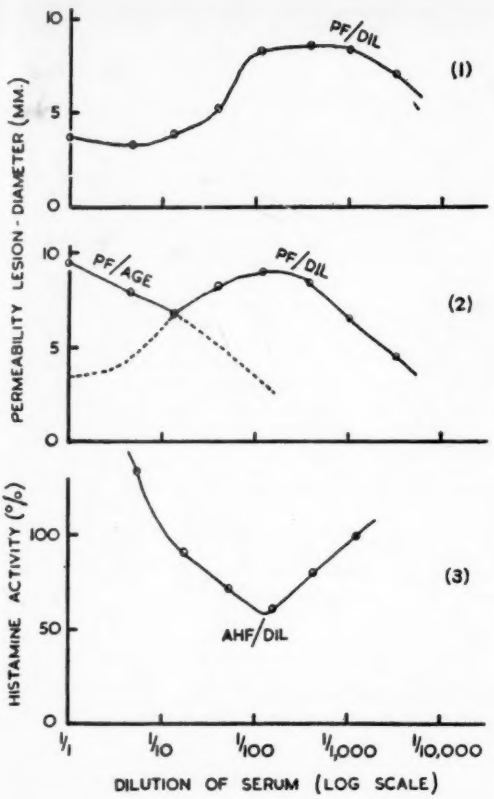
DURING a search in the guinea pig for endogenous substances responsible for the vascular and toxic phenomena of inflammation, we discovered in the blood serum of that animal a number of striking pharmacological activities, apparently due to substances of high molecular weight. Serum and serum-fractions proved to contain substances increasing the permeability of skin capillaries (permeability factors; PF), lowering the blood pressure (hypotensive factor; HF), and decreasing the smooth muscle contractor action of histamine (anti-histamine factors; AHF). None of these substances is demonstrable in fresh undiluted serum, but two are activated when the serum is diluted in 0·85 per cent saline: a permeability factor, PF/Dil; and an antihistamine factor, AHF/Dil. A second permeability factor accumulates in undiluted serum which has been held for several days at 2° C.; that is, on ageing of the serum. This we designate PF/Age.

PF/Dil. When 0·1-ml. volumes of serial dilutions of fresh serum are injected intracutaneously into depilated albino guinea pigs with pontamine blue in their circulation[1], within three minutes capillary permeability is substantially increased and the dye exudes into the injection site to form a circular blue lesion. Serum is activated only when it is diluted beyond 1/15–1/30. Maximum activation, as indicated by maximum average diameter of lesion, occurs at 1/100–1/400, and the activity is diluted out at about 1/5,000 (Fig. 1). The dilution effect is evident even in the animal from which the serum is obtained. The activation is to some extent reversible, because when diluted serum is reconcentrated at 2° C. by filtration of the saline through cellophan, it partly regains its inactivity. Unlike substances such as histamine or the histamine-liberator 48/80[1], the factor is not antagonized by mepyramine given in intra-peritoneal doses of 20 mgm./kgm. body-weight two hours before the test. It is relatively heat-labile, a 2 per cent solution of serum being largely inactivated by heating for 1 min. at 100° C.

* Working on behalf of the Medical Research Council.



PF/Age. This factor appears in undiluted serum after one day at 2° C. as a faintly blueing substance, and matures (Fig. 2) into a strongly blueing substance after three to five days. As the graph shows, its maximum is distinct from that of PF/Dil; and it is relatively inactive, the extrapolation of its curve indicating that it is diluted out at about 1/200. It is not antagonized by mepyramine.

AHF/Dil. Fig. 3 summarizes the striking effect of serum on the 15-sec. contractions of the guinea pig ileum induced by 0·05 μgm. histamine base, tested on the guinea pig ileum in an 18-ml. bath. The serum was diluted in a constant concentration of histamine, and the mixture held for a few minutes before adding to an 18-ml. organ bath. Neat or slightly diluted serum, even when it is by itself without action on the gut, enhances the histamine contraction. At about 1/40, AHF is activated; activation is maximum at about 1/100, and is diluted out at 1/1,500. Like PF/Dil, AHF/Dil is relatively heat-labile.

Activity of serum fractions. We located a permeability-factor and an anti-histamine factor in serum by the separation and assay of the protein components. A modification of the method of Kekwick and Mackay[3], using aqueous ethyl ether systems, was applied to pools of several guinea pig sera, and gave three fractions which were substantially albumin, α- + β-globulin, and γ-globulin. Either all or most of the pharmacological activity occurs in the second, the *G2* fraction, which contains 20 per cent of the serum proteins, and is about half α- and half β-globulin. The activity is further concentrated by electrophoresis of this fraction, when it moves with the α-globulin. In this *G2α* fraction, we found not only a permeability and an antihistamine factor (PF/G2α and AHF/G2α) but also a hypotensive factor (HF/G2α). All three factors, besides migrating in an electrophoretic field as globulins, fail to pass a cellophan membrane, and are heat-stable, withstanding 100° C. for 1 min., but being largely destroyed after 10 min.; and all were unaffected when held for 24 hr. in buffers ranging from *p*H 4 to *p*H 9. We have as yet found no substrate or inhibitor indicating that the active materials are enzymic. The ether treatment during fractionation is not responsible for the activation of *G2*. Amounts of the *G2α* fractions are cited below as weight of protein (6·25 × nitrogen content).

PF/G2α has 1·6 times the permeability-inducing potency of histamine base. If it is assumed that *G2α* is all permeability factor and, being retained in cellophan sacs, has a molecular weight of greater than 20,000, on a molar basis the substance is more than 90 times as active as histamine. PF/G2α has a marked affinity for the skin tissue. Given intracutaneously, it is strongly leucotaxic, and strongly promotes the adherence of circulating leucocytes to the capillary walls. Given intravenously, in doses of about 1 mgm./kgm., it produces temporary collapse of the animal, and a moderate, general increase in permeability of the skin capillaries, as demonstrated by the method of Feldberg and Miles[3]. Both the intracutaneous and intravenous effects are resistant to mepyramine. *G2α* does not liberate histamine from perfused dog or cat skin[4], or from minced guinea pig skin incubated at 37° C.[5].

HF/G2α. In intravenous doses of 0·1–0·5 mgm./kgm., *G2α* produces a fall in carotid pressure and various degrees of over-breathing in anæsthetized guinea pigs; with the larger doses the hypotension is severe and lasts ten minutes or more. The dog is equally susceptible, the rabbit less so. In all three species, repeated injections at intervals of less than 3 min. induced some refractoriness. The hypotensive effect is not changed by vagotomy; it differs from that produced by histamine, acetyl-choline or 5-hydroxytryptamine; and is unlike the Brodie effect[6].

AHF/G2α. The *G2α* fraction, in concentrations of 0·2–0·5 mgm./ml., tested in the same way as AHF/Dil, partly antagonizes 0·05 μgm./ml. histamine when mixed with it before introduction into the bath. At room temperature the reaction between the two is complete in 30 sec., and is not altered during a subsequent 80 min. The antagonism is less when *G2α* is added to the bath first and histamine is added after. The inactivation is partly reversible, because within 10–20 sec. of adding the mixture, there is a second contraction of the gut, and this, like the first, is susceptible to mepyramine. But although the binding is apparently reversible, nevertheless it is not possible to extract free histamine from the hypothetical *G2α*-histamine complex by the usual extraction process with hydrochloric acid.

We have not yet established the relationships of these six factors. Of the three permeability factors, PF/Dil and PF/Age are almost certainly distinct. PF/Dil and PF/G2α, being the most active permeability factors in fresh and fractionated serum respectively, may be identical; though PF/G2α is more heat-stable than PF/Dil. In the same way the two anti-histamine factors may be identical; but, as

with the two permeability factors, AHF/G2α is more heat-stable than AHF/Dil. With both pairs, however, the difference is not inconsistent with identity, because whole serum contains substances that confer on the heat-stable *G2α* fraction the heat lability of the permeability factors and anti-histamine factors produced by dilution. As regards the permeability, histamine and anti-histamine effects of the *G2* fraction, the physicochemical similarity of the *G2α* factors suggests their identity. We have some additional evidence that PF/G2α and HF/G2α are the same, but none as yet for other identities. As regards the two 'dilution' factors, PF/Dil and AHF/Dil, certain quantitative discrepancies suggest that if PF/Dil is identical with PF/G2α, then AHF/Dil is not the same as the AHF/G2α.

Toxic effects by mammalian sera in the tissues of *heterologous* species are not uncommon; but any estimate of their significance must be dominated by considerations of species incompatibility. The interest of the serotoxic factors we describe is threefold: (1) they are large molecular substances, effective in the *homologous* species, even in the individual animal from which the serum is obtained; (2) they are readily activated by dilution or by relatively gentle processes of serum fractionation; (3) some limited explorations suggest that the phenomena occur with the sera of mammalian species other than the guinea pig.

We may therefore be dealing with substances from the animals' own tissues which are readily activable *in vivo*, and which have a natural role in the reactions of mammalian tissues to injury. [Aug. 15.

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ASPECTS OF VITAMIN A DEFICIENCY IN RATS

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THE accepted signs of vitamin A deficiency are (1) defective low-intensity vision, (2) retarded growth leading to loss of weight, (3) hyperkeratosis (keratinizing metaplasia), and (4) xerophthalmia.

The usual biological assay is carried out on rats depleted to the point of rapid loss of weight. Such rats may or may not exhibit xerophthalmia and in most assays do not. The response is a quick resumption of growth and the cure of any xerophthalmia.

The defective low-intensity vision is measured by delayed dark adaptation, reflecting slow regeneration of rhodopsin. Retinene$_1$ (vitamin A aldehyde) and vitamin A alcohol, linked through the operation of alcohol dehydrogenase, play a direct part in scotopic vision as they form an integral part of the light-sensitive rhodopsin[1]. Whatever refinements future research may bring, the mode of action of vitamin A in scotopic vision is in broad outline a solved problem.

These results are in striking contrast to the state of knowledge concerning the growth-promoting and anti-xerophthalmic action of vitamin A. Practically nothing is known concerning the 'systemic' mode of action, and the position has been reached with vitamin A (as with vitamin D) that the problems of structure and synthesis have been solved while the essential biochemical problems are halted.

We wish to make a preliminary report of experiments which seem to break new ground.

(*a*) *The depletion process.* Newly weaned rats on a diet including light white casein (B.D.H., Ltd.) continue to grow slowly long after no vitamin A can be found in liver, kidney or blood. When fully dark-adapted, the retinas of such rats yield normal rhodopsin extracts. The light white casein contains traces of vitamin A and β-carotene, which can only be removed by refluxing the casein for several hours with ethanol. The vitamin A-activity is about 0·5 I.U./gm., assuming optimal conversion of provitamin A (β-carotene) to vitamin A. This activity is made up of 0·3 I.U. vitamin A and 0·08 μgm. β-carotene in each gram of light white casein. This may not, however, be a full measure of the potential activity of light white casein, as refluxing with ethanol is rather drastic; but it is clear that 1–2 I.U./day will maintain slow growth in rats with no signs of illness or of xerophthalmia. If, however, the light white casein component of the diet is first exhaustively extracted with boiling ethanol, growth eventually ceases and xerophthalmia appears regularly. The vitamin A in the retina and pigment epithelium does not, however, appear to be readily mobilized for use elsewhere, because the rhodopsin extractable from the retinas of xerophthalmic animals is qualitatively and quantitatively normal.

(*b*) *The specificity of vitamin A.* Several groups of workers[3–6] have claimed that growth can be restored and xerophthalmia cured in vitamin A-deficient rats given dietary supplements free from preformed vitamin A or known carotenoid precursors. Kaunitz and Slanetz[7,8] claimed that lard contained a vitamin A-replacing factor which could be concentrated in the first 7 per cent eliminated by simple molecular distillation. When given at the level 2 per cent (w/w) in a vitamin A-deficient diet, the distillate proved more effective than 7·5 I.U./day of vitamin A palmitate as a supplement to the control diet.

We have found that a lard distillate (kindly prepared for us by Dr. R. E. Stuckey and Mr. A. W. Davidson, of British Drug Houses, Ltd., London) was only partially effective at the 2 per cent dietary level, but at 5 per cent was completely effective in restoring growth and curing frank xerophthalmia; 0·6 gm./rat/day elicited a response similar to that of 6 I.U./rat/day of preformed vitamin A. The lard distillate contained no vitamin A or provitamin A (β-carotene) detectable by any colorimetric or spectrophotometric test before or after chromatography.

The importance of the lard factor is that since it is obviously distinct from vitamin A, the protective action of one or the other (or both) must be indirect unless the idea that both control the same fundamental biochemical processes is abandoned.

The deficiency syndrome (apart from its retinal aspect) may be a secondary effect correctable in alternative ways. This idea is not out of line with repeated failures to detect vitamin A in epithelial tissues[9], and it becomes necessary to inquire whether xerophthalmia is due less obviously to the absence of vitamin A than to the presence of some abnormal

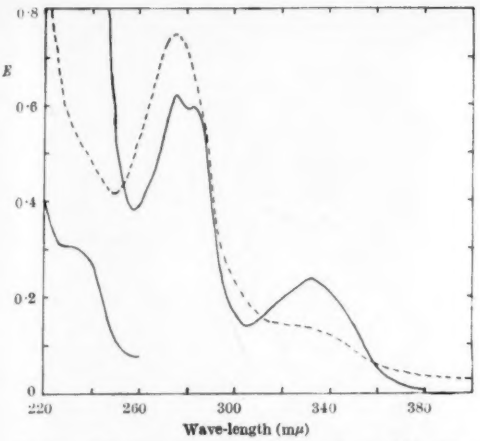

Fig. 1. (*a*) Continuous line, absorption spectrum of the richest fraction of 233 mμ, 275 mμ, 283 mμ, 332 mμ material. 220–260 mμ = 0·002 per cent solution; 250–380 mμ = 0·01 per cent solution. $E^{1\%}_{1\ cm.}$ 233 mμ, 151; $E^{1\%}_{1\ cm.}$ 275 mμ, 62; $E^{1\%}_{1\ cm.}$ 283 mμ, 59·5; $E^{1\%}_{1\ cm.}$ 332 mμ, 23·7

(*b*) Broken line, absorption spectrum of a typical additional fraction from a chromatographic separation of vitamin A-depleted rat liver lipid unsaponifiable matter. 0·0094 per cent solution. $E^{1\%}_{1\ cm.}$ 275 mμ, 80; $E^{1\%}_{1\ cm.}$ 330 mμ, 14·7. Solvent in both cases is *cyclo*hexane

metabolite(s) usually kept in check by the presence of vitamin A.

(*c*) *Liver lipid unsaponifiable matter from vitamin A-deficient rats.* The absorption spectrum of the unsaponifiable fraction of liver lipids shows $\lambda_{max.}$ 275 mμ with an inflexion near 330 mμ at the stage of depletion when no blue colour with antimony trichloride can be obtained with fractions from blood, kidney or liver. Chromatographic methods permit the concentration of a material showing (in *cyclo*hexane) $\lambda_{max.}$ 275 mμ and 332 mμ with marked inflexions at 233 mμ and 283 mμ. Some fractions obtained at the same time show $\lambda_{max.}$ 275 mμ with much weaker absorption near 330 mμ and no inflexion at 283 mμ. These materials have never been recorded as present in normal rat-liver lipid unsaponifiable fractions.

Using rats more fully depleted of vitamin A by the use of an alcohol-extracted casein diet, the amounts of abnormal constituents are found to have increased considerably. The most important fraction is eluted from alumina (P. Spence and Co., Grade 0, weakened by addition of 2 per cent water) by 8 per cent diethyl ether in light petroleum. The spectrum of the richest fraction is shown in Fig. 1, together with that of another fraction regularly obtained in the course of chromatographic separations.

The evidence indicates that a series of new substances appears in the liver in the later stages of vitamin A depletion.

In order to exclude the possibility that the new selectively absorbing materials arose from some peculiarity in our strain of rats or our experimental diets, the co-operation of Dr. S. Y. Thompson, of the National Institute for Research in Dairying, was enlisted. The livers from three groups of six rats prepared in the normal way at the Institute for vitamin A bio-assays were sent to Liverpool and examined promptly. All three sets gave extracts completely confirming our findings for rats having no liver or kidney reserves but not showing xerophthalmia.

(*d*) *Xerophthalmic eye tissue.* Tissue around the eyes of rats exhibiting marked xerophthalmia was excised and the lipid unsaponifiable fraction examined spectroscopically. The absorption curve showed three maxima (260, 270, 280 mμ) and an inflexion (320 mμ) superimposed on rising general absorption. The curve obtained with similar material from control rats (that is, weanlings on a synthetic diet supplemented with 10 I.U. vitamin A/day) showed only general absorption.

(*e*) *Abnormal constituents of other liver lipids.* Liver lipid unsaponifiable fractions from aged, worn-out horses (knackers' yard) showed $\lambda_{max.}$ 270 mμ. These horses had very low vitamin A reserves and the livers were probably richer in abnormal constituents than the livers of horses killed for meat in the abattoir. Among the substances present was Δ 3 : 5-cholestadiene-7-one, but at least one other substance with $\lambda_{max.}$ 270 mμ (in *cyclo*hexane) was present[10].

(*f*) *Cholesterol–vitamin A interactions.* In the vitamin A-deficient rat there is evidence of a significant increase in blood cholesterol[11,12], and on the other hand it has been shown that a high cholesterol intake depresses the liver store of vitamin A (rats, cockerels)[13].

(*g*) *Vitamin A depletion and the adrenal cortex.* The adrenals of thirty-one vitamin A-deficient rats, fourteen of which had severe xerophthalmia, were examined histologically and histochemically by one of us (R. G. H.). Frozen sections of both adrenals, after fixation in formal calcium, were subjected to the sudan black technique[14] for total lipids in five rats, and to the acid hæmatein method[15,16] for phospholipin in four rats, while in fifteen rats one adrenal was subjected to the sudan black technique and the other to the acid hæmatein method, and in seven rats the sudan black technique was used on one adrenal, and Schultz's method of application of the Liebermann–Burchard method for cholesterol and its esters on the other. All the rats were from a colony inbred for many generations and were litter-mates in many cases.

Fig. 2. Photomicrograph of the distribution of lipid in a part of the adrenal cortex of a vitamin A-deficient rat as shown by the sudan black technique. The zona glomerulosa (uppermost in the figure) is heavily loaded with lipid, especially top left, where there is obliteration of the sudanophobe zone, and also the outer zona fasciculata (× 71)

In contradistinction to Stoerk, Kaunitz and Slanetz[17], no 'hyaline droplet' change of the adrenal cortical cells was noted, and in agreement with earlier authors[18–20] no pathological change in the histological structure of these cells could be detected. The histochemical appearances of the adrenal cortex were, however, of great interest. The distribution of lipid, as shown by the sudan black technique, is within normal limits (Fig. 2), except that the amount of lipid in parts of the zona glomerulosa is very much increased above normal in seventeen of the rats examined (both sexes), and that the lipid distribution is uneven in parts of the zona fasciculata; the well-loaded parts of the zona fasciculata showed lipid droplets similar in distribution, size and characteristics to those previously described as 'hyaline' droplets[17]. The only exception to this appearance occurred in two rats in which lipid was completely absent from all parts of the adrenal cortex except the zona glomerulosa. The phospholipin content of the adrenal cortex, however, as shown by the acid hæmatein test, differed considerably in its distribution and loading from the lipid; in all the rats examined, apart from three, in which the distribution of phospholipin is within normal limits, the only phospholipin to be found is restricted to the zona glomerulosa, the zona fasciculata and zona reticularis being completely devoid of any coloration (Fig. 3), except in six rats in which there is an outer rim of coloured zona fasciculata cells, immediately subjacent to, and about the same thickness as, the zona glomerulosa. The distribution of cholesterol, in the adrenals examined, corresponds to that seen in the normal adrenal cortex, except in two adrenals (Figs. 4 and 5) in which the cholesterol is confined to the zona glomerulosa.

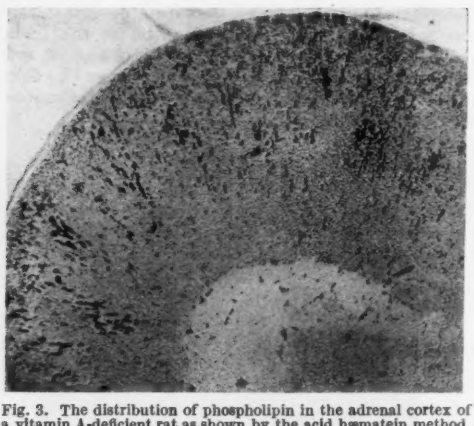

Fig. 3. The distribution of phospholipin in the adrenal cortex of a vitamin A-deficient rat as shown by the acid hæmatein method. As compared with Fig. 2, note that the phospholipin is restricted to a small quantity in the zona glomerulosa. The functioning blood vessels are also demonstrated, since the blood corpuscles are coloured by this method (× 47)

There is, therefore, a dissociated reaction of the adrenal cortex in the vitamin A-depleted rat to the sudan black technique and Schultz reaction on one hand, and the acid hæmatein method on the other. Whereas the distribution of lipid and cholesterol is within normal limits, phospholipin content is reduced and confined to the zona glomerulosa. This is a state of affairs never seen in the normal adrenal cortex[21,22] and suggests some disorder in the metabolism of adrenal cortical cells in vitamin A

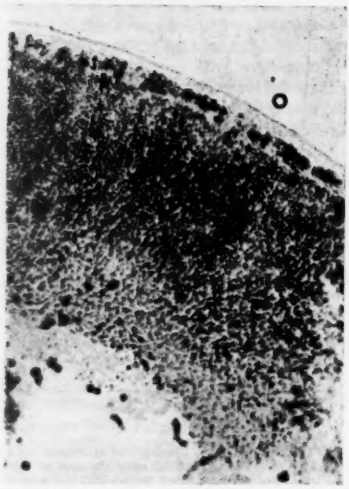

Fig. 4. The distribution of cholesterol in the adrenal cortex of a vitamin A-deficient rat as shown by the Liebermann–Burchard method. The cholesterol is confined to the zona glomerulosa and zona fasciculata, in correspondence with the sites of heavy loading with lipid (× 71)

deficiency with consequent alteration of their secretory activity. This contention is supported (*a*) by the histochemical reaction of the zona glomerulosa to both sudan black and acid hæmatein, (*b*) by the increased vascularity of the adrenal cortex (Fig. 3), and (*c*) if the presence or absence of the sudanophobe zone be taken as an indication of the level of cortical activity, by the presence of a sudanophobe zone in some of the female rats and its absence in some of the male rats, together with the absence of a sudanophobe zone in parts of an adrenal cortex where it normally is mainly found (Fig. 2). If the theory of morphological and functional independence of the adrenal cortical zones[21–23] be accepted, it would appear that there is some abnormality in the glucocorticoid activity of adrenal cortical secretion, while the secretion of mineralo-corticoids is unaffected or even enhanced.

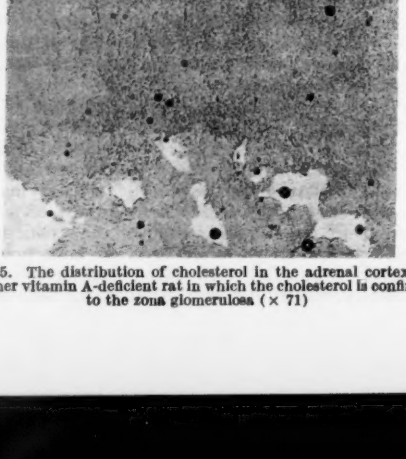

Fig. 5. The distribution of cholesterol in the adrenal cortex of another vitamin A-deficient rat in which the cholesterol is confined to the zona glomerulosa (× 71)

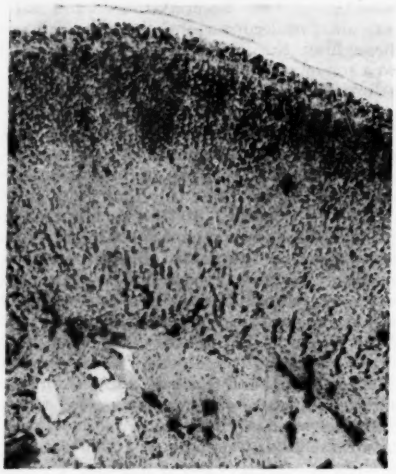

Fig. 6. The appearance of the adrenal cortex of a rat maintained on the light white casein diet (containing 1 per cent sodium chloride) for 120 days, and then given 6 I.U. vitamin A for 70 days, as shown by the acid hæmatein technique. Phospholipin is present in the zona glomerulosa and outer zona fasciculata. Blood vessels in zona reticularis can also be seen (× 71)

The adrenals of a number of rats which had shown a growth response to lard or vitamin A after being fed for a lengthy period on the light white casein diet with its very low vitamin A content were also examined. In one animal which had been given the diet (containing 1 per cent sodium chloride) for 120 days and then 6 I.U./day vitamin A for seventy days, the histochemistry of the distribution of the lipid, phospholipin and cholesterol in the adrenal cortex was normal in all respects (Fig. 6). So also were the adrenals of a rat which had been fed the same diet for 128 days since weaning but had then shown an excellent growth response to a diet containing lard (20 per cent) administered for seventy days.

A curious effect occurs with young rats on the normal light white casein diet (without 1 per cent sodium chloride).

Two rats on this diet for thirty-five days after weaning received 10 I.U./day vitamin A throughout, while two others received 10 I.U./day for thirty-two days and 500 I.U./day for the last three days. In spite of this supplementation, which is more than adequate for growth and the prevention of xerophthalmia but marginal for liver storage, all four animals had adrenals histochemically identical with those of the much older animals exhibiting the full deficiency syndrome (frank xerophthalmia).

It therefore appears that the age of the rat, the duration and level of vitamin A administration and the sodium chloride intake require further study before the histochemistry of the adrenal cortex can be fully elucidated for vitamin A-deprived rats, although the dissociated histochemical reaction in avitaminosis A is clear cut.

Discussion

It is clear that as the rats approach the terminal stages of vitamin A-deficiency, hitherto unknown metabolites accumulate in the liver. There are notable changes in the histochemical appearance of the adrenal cortex and degeneration of epithelial tissues with xerophthalmia. The rats had been so thoroughly depleted that it is impossible to attribute the new metabolites to vitamin A as a precursor, and both from the spectroscopic properties and the amounts formed, the best working hypothesis is that they result from a lifting of restraint on the dehydrogenation of cholesterol or steroid hormones.

The absorption spectrum of the main new product has not been traced to a known steroid; but it shows a marked resemblance to that of certain β-naphthalenic compounds.

Work is in progress aiming at separating, characterizing and identifying the new lipid constituents and establishing their physiological properties. The important point, however, is that the concept of vitamin A-deficiency has been widened in a manner amenable to experimental attack. The discovery that certain metabolites accumulate in other deficiency states was the prelude to rapid advances in the elucidation of modes of action of some water-soluble vitamins. Perhaps the time is ripe for similar advances in the field of fat-soluble vitamins.

It is necessary to refer briefly to *X*-disease[24] (hyperkeratosis) of cattle. This new condition has caused serious losses throughout the United States and has been the subject of much recent study. It is usually due to the presence of toxic material in the food and can be produced by administering tri-, penta-, hexa- or octochloronaphthalene (used in lubricants and tractor crank-case oil)[25], but an active fraction in processed wheat concentrates appears to be different[26]. The disease is in some ways very similar to avitaminosis A. The causative agents added to the diet result in persistently low plasma vitamin A-levels, perhaps following diminished formation of vitamin A from β-carotene[27].

The fact that hyperkeratosis in vitamin A-deficiency results in the accumulation of our new substances in the liver may well be relevant to the observations on *X*-disease, and their interpretation.

The investigations on the histochemistry of the adrenal cortex were aided by a grant to one of us (R. G. H.) from the Medical Research Council, and by the technical assistance of Miss B. Birkett. [May 22.

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LETTERS TO THE EDITORS

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Possibility of Movements of the African Migratory Locust in the Solitary Phase and the Dynamics of its Outbreaks

The discovery of 'outbreak areas' of several species of locusts, and the influence of these discoveries on the setting up and organization of preventive control, have been described by Uvarov[1]. For the African migratory locust, *Locusta migratoria migratorioides* (R. and F.), the outbreak area, first indicated by Lean[2], was defined in detail at the Fifth International Anti-Locust Conference[3] in 1938. It has since been assumed that outbreaks of this species originate in this circumscribed area in which both population-increases and phase-transformation occur. On the basis of this information, a permanent International Preventive Control Organization was formed[4].

During recent years, evidence has been accumulating which indicates that, although this is undoubtedly the area where phase transformation takes place, the population of locusts is not confined to it throughout the year, and that seasonal migrations of solitary locusts occur, followed by breeding and sometimes by great increase in numbers, in regions as far as 100 km. from the centre of the outbreak area. Since 1951 the possibility of such migrations has been studied.

The topography and vegetation of those parts of the flood plains of the middle Niger usually referred to as the outbreak area have been described in detail by Lean[2] and Zolotarevsky[5]. To the west of the flood plains, there is a semi-arid zone where sandy soils predominate and where the vegetation is of a type capable of withstanding a severe dry season lasting from October until May. The region is known locally as the Farimaké, and it is here that the temporary appearance of locust populations has been studied during the dry seasons of 1951–52 and 1952–53. The events described below followed exactly the same sequence in both years; but in 1952 the densities of adults were much higher and changes were therefore more easily observed.

In 1951, adult locusts were present in the Farimaké in November and December. No nymphs were found; but the presence of exuviæ at the bases of the grasses suggested that the young adults found had been bred in that area. At the beginning of 1952, this population of young adults disappeared and, apart from scattered individuals, the region remained unpopulated until many months later. Some weeks after the disappearance of these locusts from Farimaké, adults appeared on the flood plains in areas which had, for some months, been reported clear.

In November 1952 we returned to the Farimaké. *Locusta* adults and nymphs were again present, in great numbers. At the same time, the flood plains, with the exception of a few higher areas never covered by the water, were deserted. Densities of adults in the Farimaké reached as high as 30 per 100 paces, and from the presence of numerous nymphs it was concluded that this generation was produced there. There is therefore no doubt that successful breeding can and does take place in these semi-arid regions during the rainy season.

The origin of the adults which gave rise to these nymphs and young adults was obscure; but since a repopulation of the Farimaké occurred after our previous visit, and corresponded with a fall in densities throughout the flood plains, it was tempting to assume a movement of solitary adults from the latter to the former.

From November 1952 onwards, the changing densities of adult locusts in the Farimaké were followed in detail. There was, soon after the beginning of November, a marked fall in numbers in most areas. This continued throughout the next month until, by the middle of January 1953, the population had disappeared. It is certain that this decline in numbers was not caused by the death of these young adults. No corpses were found and not one parasite was present in the many hundreds of locusts dissected. The effect of predators appeared to be negligible except perhaps for the numbers destroyed by predatory birds patrolling the edges of the numerous bush fires; but even this loss was much less than expected. In certain habitats the disappearance of the locusts occurred very suddenly; for example, at Dioura, the population fell from a density of 15–20 per 100 paces to less than one per 100 paces between December 31 and January 2.

About one week after the last rapid decline in numbers in the Farimaké in early January, adult locusts appeared in other areas from which they were absent until then. Such adults seemed in every way similar to those previously present in the Farimaké. One of the newly populated areas was on the edge of the flood plains about 15 km. from parts of the Farimaké where densities had been high. All the others were within the flood plains and about 20 km. from the borders of the Farimaké. Locusts on the edges of the flood plains were found under normal conditions; but those within the flood plains were taken from grasses standing in water. Densities in such habitats reached as high as 15 per 100 paces. By the end of January similar adults were present on the edges of the 'toguerés' (small hills within the flood plains which are never completely covered by the floods) among the grasses recently uncovered by the floods. No hoppers were seen until nearly two months later, and there could be no doubt that these populations represented an influx from elsewhere. These habitats in the flood plains were occupied one month earlier in 1953 than in 1952; but the dates in both years corresponded with the uncovering of them by the retreat of flood water. This indicates that the adults were not far from these habitats when they became suitable, and it also suggests that movements over longer distances may be made in easy stages.

The locust population of the grass habitats above the water declined in February and, at the same time, the numbers increased on the edges of the toguerés and on a few higher parts of the plain already uncovered by the retreat of the floods. Densities in these places reached the maximum seen on the flood plains and again corresponded with those previously observed in the Farimaké.

The evidence given above is only circumstantial: all efforts to obtain direct proof were unsuccessful. In this connexion a method of marking locusts in rather large numbers and without the necessity of capturing them has now been developed. The apparatus is simple, consisting of a small spray-gun with a reservoir holding one litre of liquid, pressurized by a built-in hand pump and with a trigger mechanism, which projects a fine jet of a suspension of pigment in light oil on to the locust without catching it. With practice, individual locusts can be

marked even in flight. By this method about seventy locusts could be marked in an hour with one gun, whereas six collectors could mark only thirty by hand in the same time. Marked locusts have been captured fifteen days after marking and up to 7 km. from the place where they were marked. It has not yet been possible to test this method on a large scale, but the results so far obtained warrant further attempts to obtain a direct proof of these suspected migrations by its use.

An interesting aspect of the problem is the time of day at which these movements may occur. Despite constant observations, no spontaneous flights have ever been seen in daylight hours. Some observations at night have shown that locusts may make normal flights on being disturbed even when the temperature is several degrees lower than that recorded at dusk, and on several occasions adult locusts have been taken at light, suggesting that nocturnal flights occur.

Assuming that these large-scale movements are not exceptional, it is necessary to consider their importance in connexion with outbreak control. The Farimaké appears to be an area where breeding during summer rains may result in a great increase in population. The numbers of locusts produced there presumably determine the numbers which will later move to the outbreak area, where they would contribute to the production of incipient bands. Surveys in the Farimaké at the end of rains would possibly help the control organization to estimate the likelihood of band production in the following spring and to make preparations accordingly. Of course, the arrival of large numbers of adults will not necessarily give rise to bands in the outbreak area, as this depends on the factors operating within the outbreak area controlling successful breeding and phase transformation, and these factors have not yet been studied. In any event, however, the supervision of locust populations must not be restricted to the outbreak area proper, and a wider organization may be necessary for control purposes.

I wish to thank the Nigerian Government for allowing me to carry out these studies and the Provisional International Committee for the Control of the Migratory Locust for making them possible. My thanks are also due to Mr. M. Roblot, director of the Aire Gregarigéne, for generously placing at my disposal all the information and material of his organization, and for facilitating my work, and to Drs. B. P. Uvarov and B. N. Zolotarevsky for their help and advice.

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Rate of Flow of Polycrystalline Ice

Attempts to describe the flow of glaciers theoretically have been hindered by lack of knowledge of the actual behaviour of ice under stress, and for this reason experiments have been made on blocks of polycrystalline ice with random orientation. The method of preparation of such blocks and preliminary results of compression tests on them at − 1·5° C. have already been briefly reported[1]. Further compression tests have now been made at − 12·8°, − 6·7°, − 1·5° and − 0·02° C.

At all the testing temperatures, creep curves were obtained similar to the one shown in the previous paper[1] (an ordinary creep curve with a transient and a quasi-viscous stage), although at the higher stresses a tertiary or accelerating stage was also found, which was attributed to the effect of recrystallization.

In order to compare tests at various stresses and temperatures, the logarithm of the minimum rate of strain observed in each test has been plotted against the logarithm of the compressive stress applied to produce it in Fig. 1, different symbols being used for points at different temperatures. It will be seen that the points for any given temperature lie reasonably close to a straight line. These lines correspond to relations between compressive stress σ and rate of strain $\dot{\varepsilon}$ of the form:

$$\dot{\varepsilon} = k\sigma^n, \qquad (1)$$

where k is constant for a given temperature and n takes the value 3·3. Some tests were also made in which the stress was raised or lowered during straining. In all these cases the rate of creep soon settled down to a steady rate not very different from that which it would have had if the final stress had been applied from the start. Points corresponding to such steady rates obtained after changing the stress at − 1·5° have been added to Fig. 1, and are shown by distinctive symbols.

The variation of minimum rate of creep with temperature is such that, for the three lower temperatures, the rate of strain at any given stress is related to the temperature by

$$\dot{\varepsilon} = A \exp(-Q/RT), \qquad (2)$$

where A is constant for a given stress, R is the gas

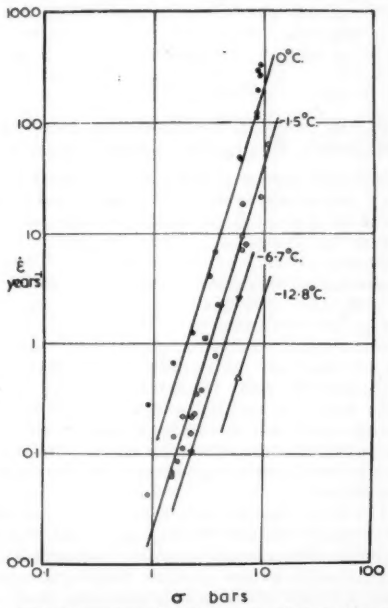

Fig. 1. Plot of logarithm of minimum rate of creep of ice against logarithm of stress. ●, points from creep tests very close to the melting point; ○, points from tests at − 1·5° C.; ◇, points from tests at − 1·5° C. after increasing the stress; □, points from tests at − 1·5° C. after decreasing the stress; ▼, points from tests at − 6·7° C.; Δ, point from test at − 12·8° C.

constant, T the absolute temperature and Q an activation energy of 33·4 k.cal. per mole. The rate of strain at the highest temperature is some four times higher than would be predicted from the formula, and this is attributed to local melting caused by temperature fluctuations.

The above results are helpful for understanding the mechanism of glacier flow, but it must be emphasized that the relations found here are not necessarily exactly those occurring in glaciers. The rate of strain plotted here is the minimum observed during the test. In tests at the higher stresses, tertiary creep produced a further acceleration after this minimum rate, which, under continued application of such stress, would make ice creep at a rate faster than the minimum; and it is far from certain that a similar acceleration would not have occurred in other tests, had they been continued for times of the order of years. The curves at the lowest stresses also gave points which may be in error, for because of experimental difficulties these tests, particularly at − 0·02° C., could not be continued long enough for the transient creep to be negligibly small. The creep curves at − 0·02° C. have therefore been re-examined, and assuming the transient creep obeys Andrade's $t^{1/3}$ law (as it appears to do within experimental error), the true quasi-viscous creep-rate has been calculated. The effect of this is to move the points at the lower stresses to lower rates of strain, and the best straight line through these points corresponds to a value of the exponent n in equation (1) of approximately 4.

Further details of these tests, as well as data obtained from sections about the grain size and recrystallization of these specimens, will be published elsewhere.

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[1] Glen, J. W., *J. Glaciol.*, **2**, 111 (1952).

A Rapid Method of obtaining Nuclear Magnetic Resonance Spectrograms

Torrey[1] has discussed the possibilities of using a relatively rapid approach to resonant conditions as a method of searching for unknown nuclear resonances, and has described methods in which H_1 (the radio-frequency field) has been pulsed. Where the establishment of resonance conditions is rapid compared with the spin-lattice relaxation time, this method gives theoretically a larger nuclear signal than that available in cases where the resonance is excited continuously or frequently. We have found that a method whereby H_1 is fixed and H_0 (the D.C. magnetic field) is rapidly swept over a relatively wide range provides not only a simple method of demonstrating nuclear resonance effects, but also one that has possibilities in rapid searching for unknown resonances.

Fig. 1 is an oscillogram which shows the quadrupole splitting of the aluminium-27 (spin 5/2) resonance in a sample of synthetic sapphire weighing 1·5 gm. The signal/noise values in this oscillogram, which took one second to trace out, compare favourably with those obtained by other methods using times as long as twelve hours to cover the same region. Figs. 2 and 3 are two other typical oscillograms obtained by this method.

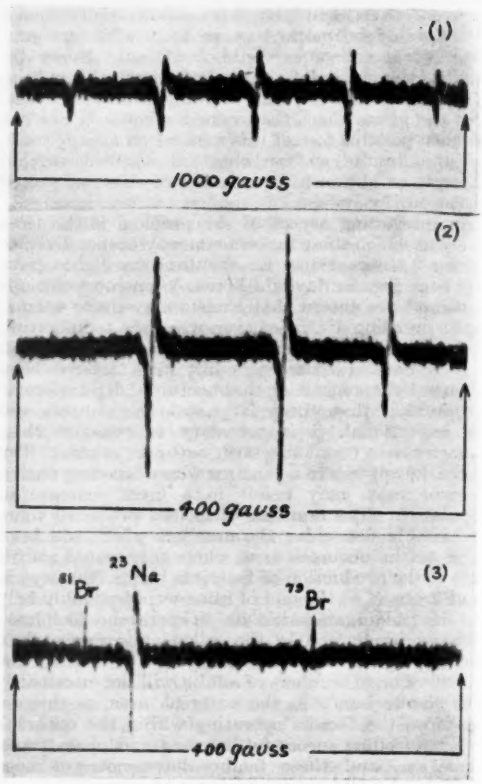

Fig. 1. Quadrupole splitting of aluminium-27 (spin 5/2) in a single crystal of aluminium oxide

Fig. 2. Quadrupole splitting of sodium-23 (spin 3/2) in a single crystal of sodium nitrate

Fig. 3. Spectrogram of a solution of sodium bromide

We have used a crossed-coil nuclear induction system similar to that described by Bloch[2]. The radio-frequency field H_1 was maintained at a frequency of 3 Mc./s. by a crystal-controlled oscillator and had the value of 0·5 gauss. The phase of the signal appearing at the output terminals of the bridge was adjusted so as to allow the dispersion component of the resonance to be observed. This signal is fed, after radio-frequency amplification, detection and low-frequency amplification, to the Y-plates of a cathode-ray oscilloscope.

A large and relatively sudden change in the D.C. field was made by short-circuiting a resistor in the driving circuit of the electromagnet. The value of the resistor was selected so that the rate of change of field was effectively linear over the region being investigated. Rates of change of 100–1,000 gauss per sec. were used. Simultaneously with the commencement of field-change, a suitable voltage was applied to the X-plate to give a single sweep of duration 1 sec. and of constant velocity. A photograph of the traverse of the spot across the cathode ray oscillograph produced a field spectrogram with the transient responses of the nuclei appearing as vertical displacements.

The samples used for obtaining the spectrograms shown in Figs. 2 and 3 were, respectively, a single crystal of sodium nitrate weighing 2 gm. and a

solution containing 0·5 gm. of sodium bromide in 1 c.c. of distilled water.

Acknowledgment is made to the Chief Scientist, Ministry of Supply, for permission to publish this communication.

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Signals Research and Development Establishment, Ministry of Supply, London.
April 27.

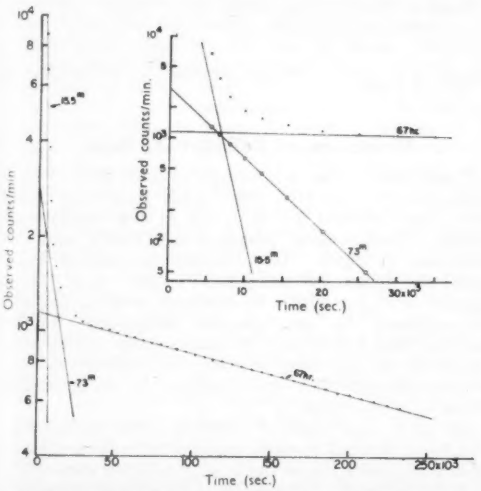
[1] Torrey, H. C., *Phys. Rev.*, **76**, 1059 (1949).
[2] Bloch, F., *Phys. Rev.*, **70**, 460 (1946).

Isomeric States of Molybdenum-93

CONSIDERABLE interest has recently been focused on the 6·7-hr. isomeric state of molybdenum-93. Experiments by Alburger and Thulin[1] at Stockholm, as well as the earlier work of Boyd and Charpie[2], definitely assigned this isomeric state to molybdenum-93. Of the limited number of reactions leading to this state, only the $^{93}Nb(p,n)^{93}Mo^*$ and the $^{93}Nb(d,2n)^{93}Mo^*$ reactions have to date shown an appreciable yield[1–3]. Irradiation of molybdenum with pile neutrons failed to yield any evidence of the reaction $^{92}Mo(n,\gamma)^{93}Mo^*$ (ref. 4). Similarly, irradiation with 23-MeV. bremsstrahlung from a betatron indicated negligible cross-section for the (γ,n) reaction[4]. However, the $(n,2n)$ reaction[3] did give some yield.

We have irradiated a molybdenum foil at 22 MeV. in our betatron beam and obtained the decay curve shown in the figure. The sample was irradiated close to the betatron target with a total of 12,000 r. delivered in a time short compared to 6·7 hr., and was then counted in large-angle geometry.

Though no 6·7-hr. activity was observed, the accuracy of our measurements allows us to estimate that no more than 20 counts/min. could be attributed to a 6·7-hr. half-life decay. From this we conclude that the integrated cross-section for the $^{94}Mo(\gamma,n)^{93}Mo^*$ reaction is less than 0·06 MeV.-barn. (The value quoted by Duffield and Knight[4] obviously refers to the ratio of the 6·7-hr. to the 15·5-min. activities; we obtained 10^{-4} for this ratio.) According to (γ,n) systematics[5], this corresponds to a peak (γ,n) cross-section of less than 10 m.barn. In these calculations, we assumed the decay scheme of Kundu, Holt and Pool[3] and data of Goldhaber and Sunyar[6] and obtained the integrated cross-section by comparison with the activity from the $^{92}Mo(\gamma,n)^{91}Mo$ 15·5-min. reaction, the cross-section of which had been previously measured[7]. We estimate that less than 1/13 of the (γ,n) reactions in molybdenum-94 go to the isomeric state of ^{93}Mo.



Decay curve of molybdenum. Each point represents 60,000 counts. Insert shows points (open circles) obtained by subtracting 6·7-hr. and 15·5-min. activity from the measured values

An examination of the spins involved in the (γ,n) and other reactions leading to this isomer clearly indicates why negligible yield is obtained and explains why the (p,n) and the $(d,2n)$ reactions on niobium form an exception, resulting in a good yield. The problem of the relative number of transition to the ground and isomeric states in a given reaction has been studied in this laboratory for a number of nuclei[7,8]. The results of these investigations may be used as a guide in this problem. In the table we have collected the data for each of the reactions pertinent to our present discussion.

REACTIONS LEADING TO $^{93}Mo^*$ AND THE SPINS OF THE INTERACTING PARTICLES

Reaction	Initial nuclear spin	Total angular momentum carried in by reacting particle
$^{92}Mo(n,\gamma)^{93}Mo,^{93*}$	0	1/2
$^{94}Mo(\gamma,n)^{93}Mo,^{93*}$	0	1 (dipole transition)
$^{94}Mo(n,2n)^{93}Mo,^{93*}$	0	$\geqslant$ 3 on the average
$^{93}Mo(d,p)^{93}Mo,^{93*}$	0	$\geqslant 0$
$^{93}Nb(p,n)^{93}Mo,^{93*}$	9/2	$\geqslant 1/2$
$^{93}Nb(d,2n)^{93}Mo,^{93*}$	9/2	$\geqslant 0$

According to Goldhaber and Hill[9] the ground state of ^{93}Mo is either $d^{5/2}$ or $g^{7/2}$, and the K/L internal conversion ratio for the isomeric transition seems to indicate an $E4$ transition. To explain the long half-life for such a high-energy isomer (2·4 MeV.), Goldhaber and Hill suggest the spin of the excited state may be 15/2 or more. In a recent communication[10] Goldhaber has shown that even a spin of 23/2 is admissible. Thus we are dealing with a nucleus of very high spin in the isomeric state and fairly large spin in its ground state.

In the case of (n,γ) thermal-neutron reactions, the intermediate ^{93}Mo compound nucleus has a spin of 1/2 at an excitation energy of about 7 MeV. We have previously shown that the cascade photons lead predominantly to the state of least spin-change[7,8]. Thus in the reaction $^{92}Mo(\gamma,n)^{91}Mo$ we have found that transitions from the intermediate state (spin 1, excitation energy $\approx$ 16–20 MeV.) to the isomeric state (spin 1/2) are favoured 5 to 1 over transitions to the ground state (spin 9/2). In ^{91}Mo the spin of the excited state is intermediate between that of the ground and isomeric states, whereas in ^{93}Mo the excited state has a spin lower than even the ground state. Thus transitions to the isomeric state are improbable. This is particularly true since only a few cascade photons are involved in thermal-neutron capture[11].

It has been shown previously[8] that the neutrons in (γ,n) reactions at the energies involved carry out an average of angular momentum of 1/2. Thus even in the most unfavourable case the intermediate ^{93}Mo compound nucleus spin will not exceed 5/2. Again, it will be seen that transitions to the isomeric state are not favoured. In the $(n,2n)$ reaction we would expect[3] intermediate nuclear spins which are larger

than for the cases just discussed, and the observed (small) $^{93}Mo^*$ activity from this reaction is not unexpected. It can be readily seen from the table that the (d,p) reaction is certainly not more promising than the $(n,2n)$ reaction and probably less.

So far, only reactions have been considered in which the initial nucleus had zero spin. For (p,n) and $(d,2n)$ reactions the initial ^{93}Nb nucleus has a spin of 9/2. The resulting higher spin intermediate states which are thus obtained favour transitions to the isomeric state. For example, even if we assume s-state protons and neutrons in the (p,n) reaction, intermediate states of spin 7/2(0·20), 9/2(0·47) and 11/2(0·33) will be formed, with the weight of each spin shown in brackets. This shows clearly why the $^{93}Mo^*$ state is reached in these two reactions and not in the others.

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April 9.

[1] Alburger, D. E., and Thulin, S., *Phys. Rev.*, **89**, 1146 (1953).
[2] Boyd, G. E., and Charpie, R. A., *Phys. Rev.*, **88**, 681 (1952).
[3] Kundu, Holt and Pool, *Phys. Rev.*, **77**, 71 (1950).
[4] Duffield, R. B., and Knight, J. D., *Phys. Rev.*, **76**, 573 (1949).
[5] Montalbetti, Katz and Goldemberg, *Phys. Rev.*, **91**, 659 (1953).
[6] Goldhaber, M., and Sunyar, A. W., *Phys. Rev.*, **83**, 906 (1951).
[7] Katz, Baker and Montalbetti, *Can. J. Phys.*, **31**, 250 (1953).
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[9] Goldhaber, M., and Hill, R. D., *Rev. Mod. Phys.*, **24**, 179 (1953).
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Spiral Morphology of Boron Particles

In recent work on the ultimate analysis of decaborane[1] the permeability of palladium to hydrogen was utilized to separate the elements formed in the pyrolysis of this compound. Decaborane, contained in sealed palladium capsules, was decomposed by heating at 900° C., leaving a solid pyrolysis residue

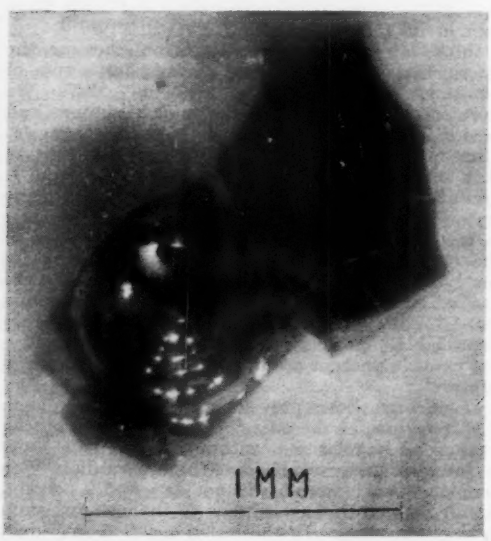

Fig. 1. Boron particles from pyrolysis of decaborane

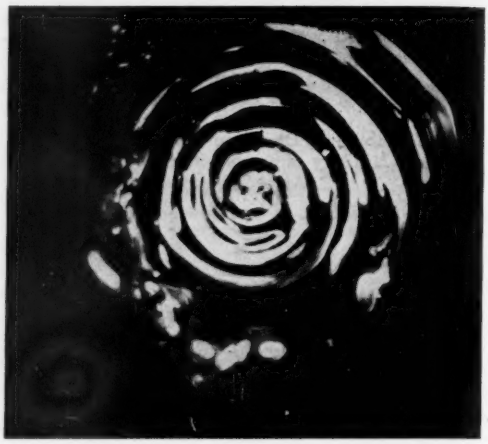

Fig. 2. Boron particle from pyrolysis of decaborane (dark-field illumination. × 80)

of boron containing approximately 0·5 atom per cent palladium. The residue was in the form of hard, shiny black granules (0·5–1·0 mm.), the X-ray diffraction pattern of which consisted of three diffuse rings.

Microscopic examination disclosed that many of the particles possessed an external spiral morphology, as shown in Fig. 1. This is more clearly seen in the photomicrograph (Fig. 2) prepared by Dr. F. H. Horn, of this laboratory. The spiral lacked the sharp step heights usually observed in the spiral growth patterns of crystalline materials. It more closely resembled a rolled-up rug viewed end on.

At present we can offer no conclusive mechanism for the growth process which produced this unusual external morphology unaccompanied by any X-ray crystallinity. Pyrolysis of anthracene under the same conditions produced a non-crystalline carbon residue with no regular external structure.

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June 15.

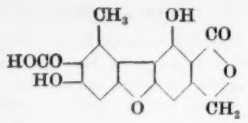
[1] Simons, E. L., Balis, E. W., and Liebhafsky, H. A., *Anal. Chem.*, **25**, 635 (1953).

Structure of Porphyrilic Acid

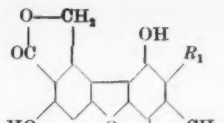
Porphyrilic acid, a sparingly soluble acid of high melting point (approx. 298° after darkening from 270°), was isolated by Zopf[1] from the crustaceous lichens *Haematomma porphyrium* (Pers.) and *H. coccineum* (Dicks.). Both lichens contained other acids, the latter, for example, (−)usnic acid. Porphyrilic acid, for which no analyses were given, was characterized by an intense indigo-blue colour reaction with ferric chloride and a green colour with a solution of bleaching powder. On thermal decomposition, porphyrilic acid yielded a characteristic product, porphyrilin.

An acid, undoubtedly identical with porphyrilic acid, has now been isolated together with lævorotatory usnic acid from a lichen material consisting essentially of *H. coccineum*. The acid is extremely sparingly soluble in most organic solvents and is conveniently purified through its cyclohexylamine salt,

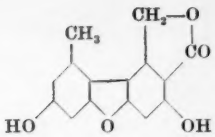
$C_{16}H_{10}O_7 . C_6H_{11}NH_2$, m.p. 274–278° (decomp.). The acid crystallizes with one molecule of water ($C_{16}H_{10}O_7.H_2O$). When heated to the melting point (about 280°) it looses carbon dioxide, and porphyrilin (m.p. about 300° with sublimation)—$C_{15}H_{10}O_5$—is formed. It crystallizes with one mole of water and gives the blue ferric chloride reaction.



I



II R_1=COOH R_2=H
III R_1=H R_2=COOH



IV

The presence of a carboxyl group in porphyrilic acid is indicated by the composition of the cyclohexylamine salt and of porphyrilin. Porphyrilic acid and porphyrilin contain one C—CH_3 group but no methoxyl groups. The acid gives a diacetate $C_{16}H_8O_5(OCOCH_3)_2$, m.p. 262–265° (decomp.), and on methylation with diazomethane yields methyl O-dimethyl porphyrilate, $C_{15}H_7O_3(OCH_3)_2COOCH_3$, m.p. 270–272°, which may be hydrolysed to O-dimethylporphyrilic acid, $C_{15}H_7O_3(OCH_3)_2COOH$, gradually decomposing from about 325°. Porphyrilin yields a dimethylether, $C_{15}H_8O_3(OCH_3)_2$, m.p. 267–269°. Hence both porphyrilic acid and porphyrilin contain two phenolic hydroxyl groups. Both compounds couple with diazotized amines to red azo dyes. Hydrolytic titration of O-dimethylporphyrilic acid indicates the presence of a lactone group. These facts account for six of the seven oxygen atoms in porphyrilic acid. Since the substance exhibits no carbonyl functions the remaining oxygen atom must be present as an ether link.

An insight into the carbon skeleton of porphyrilic acid was gained by degradation of O-dimethylporphyrilic acid. Oxidation with permanganate afforded a tetracarboxylic acid, $C_{12}H_3O(OCH_3)_3(COOH)_4$ (tetramethyl ester m.p. 221–223°), which when heated gave a yellow dianhydride, $C_{12}H_3O(OCH_3)_2(C_2O_3)_2$, m.p. about 330–335° with sublimation. On boiling with strong hydrobromic acid, the dianhydride underwent demethylation and partial decarboxylation to a dihydroxy dicarboxylic acid, characterized as the tetramethyl derivative, m.p. 149–150°. The acid was further decarboxylated by heating with quinoline and a copper chromite catalyst to a phenol *A*, $C_{12}H_8O_3$, m.p. 162·5°–164° (diacetate m.p. 141–142°).

Considering the predominant role of orcinol in lichen chemistry the most probable structure of *A* seemed to be either 3.7-dihydroxy-, 1.9-dihydroxy- or the unsymmetrical 1.7-dihydroxy-dibenzofuran. The two first substances are known, m.p. 241° and 215° respectively. The hitherto unknown unsymmetrical substance was prepared by mixed Ullmann coupling of 2-iodoresorcinol dimethylether and (excess) of 4-iodoresorcinol dimethylether. All three tetramethoxy-biphenyls were isolated. The 2,6,2′,4′-tetramethoxy biphenyl, m.p. 106–107°, was demethylated (HBr) with simultaneous elimination of one molecule of water and formation of 1.7-dihydroxydibenzofuran, m.p. 163–164·5° (diacetate m.p. 141-142°). The synthetic substance and its diacetate were identical with *A* and its diacetate (mixed m.p.).

From these results and the above genetic considerations, porphyrilic acid very probably possesses either structure I, II or III. These formulæ all account for the colour reaction with ferric chloride and for the easy decarboxylation to porphyrilin. However, porphyrilic acid but not porphyrilin forms a borate complex, as indicated by a comparison of the R_F value on borate-impregnated[3] and phosphate-impregnated paper of *p*H 8·7 (R_F = 0·03 and 0·15 : 0·69 and 0·72 respectively, *n*-butanol–water). This indicates the presence of a hydroxyl group in the *ortho* position to a carboxyl group in porphyrilic acid, and structure III is therefore less probable.

Porphyrilic acid, undoubtedly, is formed in Nature by unsymmetrical oxidative coupling of simple phenols of the orsellinic acid series. Porphyrilin is an isomer of strepsilin[2] (IV), which also gives a blue ferric chloride reaction as well as green colour with bleaching powder and is a derivative of the symmetrical 3.7-dihydroxy-dibenzofurane.

A detailed account of this work will appear shortly in *Acta Chemica Scandinavica*.

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June 23.

[1] *Zopf. Ann.*, **346**, 111 (1906).
[2] Shibata, *Acta Phytochim.* (Tokyo), **14**, 177 (1944).
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New Molecular Compounds of Graphite

The only molecular compounds of graphite previously reported in the literature are the graphite–ferric chloride compound, described by Rüedorff and Schulz[1], the compounds of graphite with chromyl chloride and chromyl fluoride reported by Croft and Thomas[2], and the compound with aluminium chloride noted by Croft[3]. This communication records the successful preparation of many new compounds of the same type.

Crystalline flake graphite with the size range minus 65 plus 100 mesh was heated with an excess of test substance, usually in a sealed tube. The procedure for heating and for detection of reaction necessarily varied from substance to substance: details will be published elsewhere.

Results, together with those for chlorides previously known to react and marked by an asterisk, are summarized in the accompanying table. By non-intercalation is meant that less than 0·5 per cent of the test substance was detected by analysis in the treated graphite.

The specificity shown by graphite in compound formation is remarkable. It was found that either a substantial quantity (15–83 per cent by weight in a compound) or none at all of a test substance could be intercalated. With the exception of iodine and boron, chlorides of non-metals were not occluded. This indicated that covalency of a substance is not a prime requisite for its intercalation in graphite. The successful intercalation of the chlorides of iodine

Substances intercalated in graphite			Substances not intercalated in graphite			
$CuCl_2$	$SbCl_5$	$RhCl_3$	Cu_2Cl_2	$SiCl_4$	$AsCl_3$	$PdCl_2$
$CuBr_2$	$BiCl_4$	$PdCl_4$*	$BeCl_2$	$GeCl_4$	$SbCl_3$	$PtCl_2$
$AuCl_3$	$TaCl_5$	$PtCl_4$	$MgCl_2$	$TiCl_4$	$BiCl_3$	$LaCl_3$
BCl_3	$FeCl_3$†	ICl†	$CaCl_2$	$SnCl_4$	VCl_4	$CeCl_3$
$AlCl_3$†	$CrCl_3$	ICl_3	$BaCl_2$	$SnCl_4$	SO_2Cl_2	$PrCl_3$
$AlBr_3$	CrO_2Cl †	YCl_3	$ZnCl_2$	$PbCl_2$	$SOCl_2$	$NdCl_3$
$GaCl_3$	CrO_2F_2†	$SmCl_3$	$CdCl_2$	$PbCl_4$	$SeOCl_2$	$ErCl_3$
$InCl_3$	$MoCl_5$	$GdCl_3$	CdI_2	$ThCl_4$	$TeCl_4$	$ScCl_3$
$TlCl_3$	WCl_6	$YbCl_3$	Hg_2Cl_2	ThI_4	$MnCl_2$	
$ZrCl_4$	UCl_4	$DyCl_3$	$HgCl_2$	PCl_3	$CoCl_2$	
$HfCl_4$	UO_2Cl_2	$EuCl_3$	CCl_4	PCl_5	$NiCl_2$	
	$ReCl_4$					
	$CoCl_2$*					
	$RuCl_3$					

* Normally unstable, but stable when intercalated in graphite.
† Previously known to react.

is attributed to the considerable electron affinities of these compounds. Among the metal chlorides tested, only those in which the cation normally exhibits multivalence and which were in their higher valence states were intercalated. Thus $SbCl_5$, $BiCl_4$, $PtCl_4$ and $CuCl_2$ were readily intercalated; but the lower chlorides $SbCl_3$, $BiCl_3$, $PtCl_2$ and Cu_2Cl_2 did not react with graphite over a wide range of conditions. The intercalated chlorides of aluminium, gallium, indium, thallium, yttrium and zirconium were, unlike the other chlorides, hydrolysed *in situ* by washing, suggesting a distinct sub-group in the above list of molecular compounds.

Since multivalence is associated with an electronic configuration generally involving unsaturated penultimate electron shells, it is likely that these molecular compounds of graphite owe their existence to the transference of electrons from the incompletely filled bands of graphite to the intercalated metallic cations. This transfer would occur when the cations possess their maximum electron affinities, as in their higher valence states. Thus one would expect paramagnetism to be a good criterion of the possibility of intercalation. A good correlation was found to exist between paramagnetism of the test substance and successful intercalation in graphite. This theoretical treatment has been developed in some detail and appears to offer a satisfactory explanation for the formation and stability of molecular compounds and also a basis, of particular value from an applied point of view, for predicting the specificity of graphite for certain chlorides. One conclusion derived from the theory is that it should be possible to form molecular compounds of graphite by allowing the latter to react with paramagnetic salts other than halides. I have confirmed this conclusion for the sulphides CuS, FeS_2, V_2S_5, Sb_2S_5 and the oxides Sb_2O_5 and MoO_3. The successful intercalation of CrO_2Cl_2 and CrO_2F_2 noted by Croft and Thomas[2] also supports this conclusion.

A more detailed account of these investigations will be published elsewhere.

I am grateful to Mr. R. G. Thomas and Dr. A. L. G. Rees for advice and also to Mr. L. J. Rogers for assistance.

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'Leuco-cyanidin' and Epicatechin

Bate-Smith and Swain[1] have recently come to the conclusion that the so-called condensed, 'catechin', tannins are in many instances identical with the 'leuco-anthocyanins' described by Robinson and Robinson[2]. Recent work here has suggested that the catechins and 'leuco-anthocyanins' are extremely closely related.

A 'leuco-cyanidin' has been isolated from cacao beans which moves as a single discrete spot when chromatographed in amyl alcohol – acetic acid, *n*-butanol – acetic acid, phenol or distilled water[3]. When heated for several minutes with 10 per cent hydrochloric acid, although cyanidin was produced, the main product was a reddish-brown precipitate, as found by Bate-Smith and Swain[1]. Numerous other polyphenols could be detected by paper chromatography and the reaction is obviously very complex.

Although leuco-cyanidin is stable in water at 100° C. for 3 hr., with 0·1 *N* hydrochloric acid for 5 min. at 100° C. an extremely interesting change takes place, as shown in Fig. 1. A catechin (*E*) and a reddish-brown precipitate (*P*) were the main products. The product (*E*) gave all the catechin colour reactions[4] and moved with identical R_F to (−) epicatechin in all four solvents, and on extraction from the paper and boiling was partly isomerized to a substance indistinguishable from (−) catechin on chromatography[5]. By quantitative chromatography[3], it was estimated that, of the leuco-cyanidin changed, 31 per cent (−) epicatechin and 6 per cent (−) catechin was formed. Further heating does not give increased yields due to condensation. No sugars were liberated.

When (−) epicatechin was treated under identical conditions 64 per cent was unchanged, and 16 per cent of (−) catechin had been produced by isomerization, as well as polymerized material. The conversion to (−) epicatechin, taking into account the subsequent epimerization and polymerization, is therefore of the order of 50 per cent. The nature of the (*X*) fraction (see Fig. 1) is unknown. The other major product is a reddish 'phlobaphene' (*P*) which is precipitated on standing. A search was made for milder conditions of hydrolysis; 1 per cent (w/w)

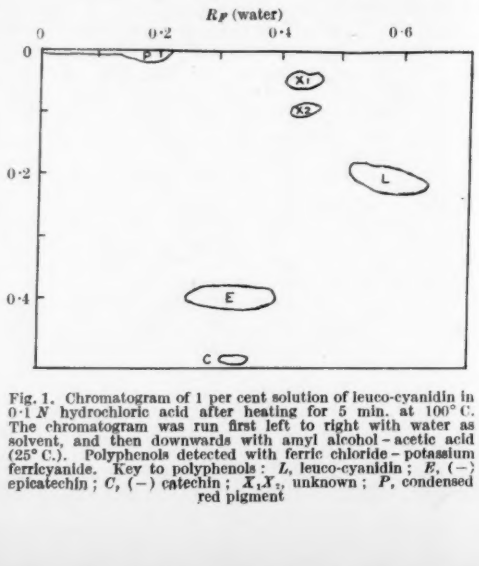

Fig. 1. Chromatogram of 1 per cent solution of leuco-cyanidin in 0·1 *N* hydrochloric acid after heating for 5 min. at 100° C. The chromatogram was run first left to right with water as solvent, and then downwards with amyl alcohol – acetic acid (25° C.). Polyphenols detected with ferric chloride – potassium ferricyanide. Key to polyphenols: *L*, leuco-cyanidin; *E*, (−) epicatechin; *C*, (−) catechin; X_1X_2, unknown; *P*, condensed red pigment

oxalic acid at 100° C. for 5 min. in water or alcohol caused a similar conversion, as did 0·1 *N* acetic acid when heated for 1 hr. at 100° C. The reddish 'phlobaphene' and the (*X*) fraction were formed in every case.

These findings indicate an extremely close relationship between (−) epicatechin and a moiety of the leuco-cyanidin molecule. They suggest that the production of cyanidin in strong acid is probably due to a side reaction between two parts of the molecule, and the name 'leuco-anthocyanidin' is a misnomer.

It is hoped to publish this investigation in full detail shortly.

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Gradient-Elution Analysis in Inorganic Paper Chromatography

We have recently read with great interest the account of gradient-elution analysis to the International Analytical Congress[1]. This type of elution with a continuously changing solvent appeared to be of special value for separations of metal ions in butanol containing hydrochloric acid, as the R_F values change considerably from low to high acid concentrations.

In the investigation described here, the apparatus employed was even simpler than that for column separations. A large chemical jar 30 cm. high was used as development chamber for ascending development. The first solvent, in this case butanol saturated with 1 *N* hydrochloric acid (100 ml.), was poured into the bottom of the chamber and agitated with a magnetic stirrer. The chromatogram was then stood at the bottom of the chamber and the second solvent (here concentrated hydrochloric acid) added from a burette which was fixed through a hole in the cover of the jar.

The rate of addition of solvent was in relation to the speed of development. Each centimetre was first marked on the paper and the hydrochloric acid added in eleven 2-ml. portions for each of the first 11 cm. ascended; then, as the yellow ferric iron spot appeared to move too slowly, the rate was increased to 4 ml. per cm. for another 4 cm. of development. In all, the solvent ascended 15 cm. in about four hours.

Fig. 1 shows the spots obtained for ferric iron, cobalt and for a mixture of thallium, mercury, cadmium, bismuth, iron, nickel, copper and cobalt. The last-mentioned mixture was completely resolved into eight well-separated spots, which is impossible to achieve with any simple mixture of butanol and hydrochloric acid so far described.

One defect of gradient elution analysis was noted with respect to ferric iron. Ferric iron has R_F 0·1 in butanol saturated with hydrochloric acid, 0·4 in butanol saturated with 3 *N* hydrochloric acid and 1·0 in butanol – 30 per cent concentrated hydrochloric acid.

As shown in the photograph, gradient elution produces a long 'comet'. This is formed also when

Fig. 1. From left to right: ferric iron with comet, cobalt, a mixture containing thallic (fastest), mercuric, cadmium, bismuth, iron, nickel, copper and cobalt (slowest) ions. The black specks are due to rust which was accidentally introduced from a fume chamber used for drying the chromatogram. All elements were detected by spraying with a solution of ammonium sulphide

more or less hydrochloric acid is added to the butanol solvent. We suggest that comet formation is due to the fact that the ferric ion in hydrochloric acid exists as the following complexes in equilibrium:

$$FeCl^{++} \rightleftharpoons FeCl_2^{+} \rightleftharpoons FeCl_3^{0} \rightleftharpoons FeCl_4^{-}.$$

The un-ionized form would certainly be the most solvent-soluble; hence, if the gradient of hydrochloric acid approached the ferric ion spot so as to form $FeCl_3^0$ at its front, but with a little higher concentration of acid the anion $FeCl_4^-$ is formed, then the movement of the lower portion of the spot will be more and more retarded, thus forming the comet. This type of comet could also form with other elements which exist in such equilibria; however, a certain critical gradient appears to be necessary for comet formation, as, for example, mercuric and thallic ions form round spots.

There appear to be numerous solvent systems in inorganic paper chromatography where gradient elution would improve separations; work on some of these is in progress.

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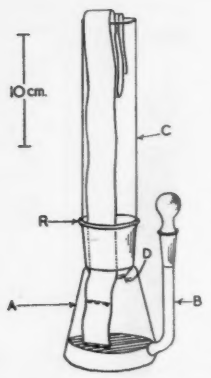
Two-dimensional Paper Chromatography of Radioactive Substances

An automatic scanning technique employing a Geiger–Müller tube for the location and estimation of radioactive substances separated on unidimensional paper chromatograms has been described[1]. The application of this technique to two-dimensional chromatograms is tedious because a large sheet of paper has first to be cut up into the equivalent number of unidimensional strips and each strip scanned separately. To obviate this difficulty, an alternative technique to the conventional form of two-dimensional paper chromatography has been



successfully developed for the application of two or more solvent systems to the same labelled mixture.

In the conventional technique[2], the mixture is partly resolved by running with the first solvent in a direction parallel to one edge of a square sheet of paper. The paper is then turned through a right-angle and run with a second solvent. The separated substances are finally located by treating the paper with a suitable reagent. If, however, the components separated in the first solvent could be located accurately at that stage without decomposing them, then only those parts of the paper containing these components need be developed in a second solvent. With radioactive components, this can, in fact, be done by the scanning techniques already mentioned. The problem then is to concentrate these components, or better still only those components known to be further resolvable, by running with another solvent, on to a second strip of paper so that it can be run in a second solvent under unidimensional conditions. This may be done readily by the following method.

The boundaries of the radioactive zones separated unidimensionally in the first solvent are lightly marked off in pencil while the strip is being scanned radiometrically[1]. The corresponding sections of paper are then cut out and attached by means of a stainless steel pin to the bottom of a new strip. Each strip is then wedged lightly between the ground-glass surfaces of the *B*-50 neck of the empty elution unit illustrated. The unit consists of a flat-bottomed flask *A* provided with a side-tube and stopper *B*. The extended *B*-50 cone is sealed off at the lower end *D* so that the flask is closed. The strip is adjusted so that the attached section hangs to within 1 cm. or so from the bottom of the flask. One unit of the size illustrated will accommodate four 1-in. strips equally spaced around the joint. The eluting solvent (which must be volatile) is then added through *B* until the section is immersed to a depth of about 1 mm. The solvent rapidly ascends the strip until it emerges just above the rim *R*, when it is no longer in equilibrium with its own vapour. It therefore evaporates and the eluted substance becomes concentrated in a narrow band (about 0·5 cm.) at the solvent front which is on the new strip of paper. *C* is gently removed, the section detached and the concentrated zone chromatographed in the second solvent and finally scanned. Evaporation may be aided by placing the unit in a gentle air stream (for example, fume cupboard draught). When an acid – water – alcohol mixture was used for concentrating phosphate esters labelled with phosphorus-32, elution was complete and quantitative within a few hours and contamination of the ground-glass surfaces was negligible. Even in still air at 0° C. (conditions used for handling unstable esters) the solvent front rarely ascended more than 2–3 cm. above *R*. Subject to the chemical stability of the substances, the whole process can be repeated, thus effecting 'multidimensional' chromatography. The method also proved to be useful for concentrating the material of several paper sections (three or four attached to one strip) until sufficient was obtained for chemical tests.

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Reduction of Liquid Flow in Paper Electrophoresis

Interpretation of the results of paper electrophoresis[1-3] is complicated by liquid movement in the paper, due to hydrostatic flow, attainment of equilibrium in the paper, and electro-osmosis. Hydrostatic flow, due to the difference in level of buffer in the electrode vessels, can be eliminated by arranging a siphon between the vessels[1].

Liquid flow has been further examined in this laboratory with the object of identifying the underlying factors and minimizing their effects, using the apparatus of Woods and Gillespie[3], which is a modification of that described by Cremer and Tiselius[1]. With this arrangement, movement of liquid due to evaporation from the paper is minimized by clamping the paper between glass plates; but liquid flow due to other factors is considerable. Movement of spots of trinitrobenzene and *o*-nitroaniline has been used for following liquid flow. At *p*H values of 5·0 and below, trinitrobenzene is uncharged and its position is determined by spraying with 5 per cent dimethyl aniline in ethanol which produces a pink colour, intensified by exposure to ammonia gas. At *p*H 7 and above, *o*-nitroaniline is uncharged and forms a yellow spot.

In the initial experiments, after soaking the strip in buffer and blotting it between filter papers[1,3], three spots of the indicator solution were applied, one at the centre and the other two 8 cm. on either side. In the absence of an applied potential difference, considerable inward flow of buffer solution from each end was observed, even when the edges of the two glass plates were sealed, due to the unsaturated condition of the paper. Thus, on electrophoresis, the apparent mobilities of spots moving from the centre of the paper would be low.

By applying the spots prior to wetting the paper, allowing most of the indicator solvent to evaporate, then saturating the strip with buffer and, without blotting, immediately clamping it between the glass plates, no appreciable spreading of the spots occurred. Moreover, by sealing the plates along the edges and binding them transversely with adhesive cellulose tape, evaporation was reduced and fairly uniform flow was observed throughout the length of the sealed region of the strip when the current was passed.

The use of buffer-saturated paper completely arrested inward flow from the ends and replaced it by a very slight outward flow due to evaporation of the buffer from the exposed ends of the strip. When proteins were applied to the paper before saturation with buffer, they were adsorbed more

strongly than were the indicators. This effect was avoided, without altering the liquid flow, by spotting the protein solution on the buffer-saturated strip at a locally blotted site.

Electro-osmotic flow is due largely to the migration of hydrated cations which dissociate from the carboxyl groups of the paper. A corresponding but much smaller effect occurs at the glass – water interface. With an acidic or negative paper the liquid moves towards the cathode, and with a basic or positive paper it would be expected to flow towards the anode. Tiselius[4] recently reported that negative and positive papers had been prepared in his laboratory by Perath and Flodin for use in paper electrophoresis, using 2-amino-ethyl sulphuric acid for the latter. We have prepared basic paper by immersing strips of 3 *MM* Whatman paper in 0·1 *M* periodic acid at room temperature to form dialdehyde groups in the paper, which are then coupled with hydrazine derivatives. The periodate-treated paper is washed in tap water for 30 min. and immersed in a 10 per cent solution of Girard's *P* reagent[5] (pyridinum acethydrazide chloride) in a mixture of 9 vol. of ethanol and 1 vol. glacial acetic acid at 70° C. for 30 min. and again washed in running water. The amount of the Girard's reagent reacting with the paper is determined by the time of treatment with periodic acid (Table 1). Aminoguanidine and 2-aminoethylhydrazine[6] have also been coupled to paper in this way.

Table 1

Time of periodic acid treatment (min.)	0	10	30	60
Nitrogen content of paper (per cent) on treatment with Girard's *P* reagent	0·022	0·030	0·037	0·057

Untreated paper contained 0·008 per cent nitrogen.

The contraction in length of the papers during treatment was less than 1 per cent, and there was neither thickening, discoloration nor any noticeable reduction in wet strength.

The cathodic flow of liquid in untreated paper increased with *p*H, corresponding with increased dissociation of the carboxyl groups. In order to prevent electro-osmotic flow as the *p*H of the buffer was raised, it was necessary to lengthen correspondingly the initial treatment with periodic acid. Paper oxidized with periodic acid coupled with aminoguanidine was positive at and below *p*H 5; at *p*H 7 and above this value the flow was the same as in untreated paper. Treatment of the paper with periodic acid alone for periods up to 40 min. increased the acidity only slightly as determined by electro-osmotic flow. However, oxidation with bromine and alkali[7] produced a more strongly acidic or negative paper, with marked cathodic flow at *p*H values of 4 and above. At *p*H 2 no flow was observed, due, presumably, to suppression of ionization. An even more strongly negative paper, prepared by coupling paper oxidized with periodic acid with phenylhydrazine *p*-sulphonic acid[8], revealed no change in the cathodic flow even when the *p*H of the buffer was reduced from 8 to 2. The buffers employed were: *p*H 2, 4 and 5, 0·1 *M* acetate; *p*H 7, 0·1 *M* phosphate; *p*H 8, 0·04 *M* veronal hydrochloride; *p*H 9, 0·1 *M* glycine.

The acidic or basic nature of the treated papers was further evidenced by the uptake of the basic dye methyl green or the acidic dye naphthol green respectively, when the papers were immersed in an aqueous solution containing both dyes and then washed in water. After similar exposure to the mixture of dyes, untreated paper retained only a slight basic stain. These ion-exchange properties are in keeping with previously described experiments on chemically modified cotton cellulose[9].

The charge on the paper used in electrophoresis experiments not only affects the overall mobilities as a consequence of electro-osmosis, but it also causes ions of opposite charge to be adsorbed. Thus when using untreated paper, which carries a slightly negative charge, any protein components migrating cathodically tend to trail, and inferior separations of mixtures are obtained. We have observed this effect with the components of horse-radish peroxidase[10] and found a marked change in the electrophoretic pattern on changing from untreated to positively charged paper.

It is probable that neutral or positive paper may also be of value in the chromatography of basic substances which normally trail due to adsorption.

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Gas Content and Electrolytic Etching Behaviour of Aluminium

If aluminium is etched in an electrolytic cell, with a 0·2 *N* sodium chloride solution as the electrolyte, at a temperature of 90° C., and using current densities of 0·1–0·2 amp./cm.², different patterns of attack may be observed with different samples of aluminium. The latter, which were in the form of rolled foil, were all of a similar nominal purity grade—sold as "99·8% Al"—and were given an identical etching treatment. With some of them the attack was widespread over the whole surface, while with others it was strongly localized, producing deep pits, with large parts of the surface remaining unattacked. Acid or alkaline cleaning treatments, applied before the electrolytic etch, failed to alter the general picture, that is, it was still possible to distinguish between the two types of attack.

No correlation between the metallic impurities of the samples and their etching behaviour was found. However, when the aluminium was heated to 600° C. for not less than one hour, blistering occurred with some samples, and a strong correlation was found between the blistering and the etching behaviour. Those samples most prone to blistering were also those in which localized etching and pitting was observed.

It is emphasized that the etching behaviour referred to is that shown by the foil before heating. No blistering or internal cavities could be observed

when examining cross-sections of the unheated foils under the microscope; thus the localized attack is not the result of the linking up of cavities already in existence.

It is known that blistering in heat-treated aluminium is due to hydrogen; hence it would seem that the etching behaviour is correlated with the hydrogen content of the aluminium, in the sense that the higher the hydrogen content the more localized the attack. For example, very severe localized attack will occur in a specimen which, on heating, gives a cavity to metal ratio of 0·04.

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A Cytochrome Peroxidase from *Pseudomonas fluorescens*

A crude extract of *Pseudomonas fluorescens* was found to oxidize a reduced dye, 2,6-dichlorobenzenoneindo-3′-chlorophenol. The activity in the crude extracts seemed similar to the 'dye oxidase' activity described by Smith and Stotz in plant tissues[1]. On partial purification, the 'dye oxidase' activity was always associated with a pigmented component. Spectral analysis of this pigment in the reduced and oxidized state indicated that it had an absorption similar to the respective states of cytochrome *c*. However, this pigment is not reduced by reduced triphosphopyridine nucleotide using purified triphosphopyridine cytochrome *c* reductase obtained from liver[2].

Additional evidence suggesting a difference between animal cytochrome *c* and this pigment was found by placing a mixture of the two on an 'Amberlite *IRC*-50' column in 0·1 *M* phosphate buffer at *p*H 7·5, according to the method of Neilands[3]. The animal cytochrome *c* formed a sharp red band whereas the bacterial pigment, along with most of the 'dye oxidase' activity, passed through the column. Furthermore, reduced cytochrome *c* added to the bacterial extracts is not oxidized under the same conditions in which the bacterial pigment is oxidized.

The reduced pigment was found to be oxidized by hydrogen peroxide, suggesting a cytochrome *c* peroxidase mechanism. Addition of hydrogen peroxide to the extracts and reduced dye carried the oxidation of the dye to completion (see Fig. 1, curve *A*). The 'dye oxidase' activity, observed in the absence of added hydrogen peroxide, was found to be due to hydrogen peroxide formed on reduction of the dye by hydrogen gas using palladium–asbestos as catalyst, as the addition of catalase inhibited completely the reaction (curve *B*). The reduced dye acts chemically with the pigment, giving the oxidized dye and reduced pigment respectively.

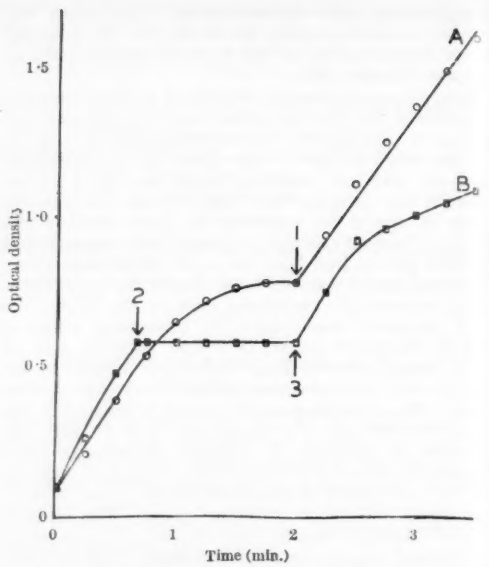
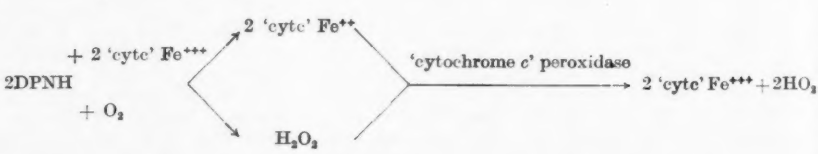


Fig. 1. All values are measured at 575 mμ. The reaction mixture consists of 0·01 c.c. of the crude extract, 2·3 c.c. of the reduced dye, and 0·1 *M* orthophosphate buffer at *p*H 7·5 to bring the total content to 3·0 c.c. The additions are, respectively: (1) 2 μ*M* hydrogen peroxide; (2) 1 mgm. Armour catalase; and (3) 10 μ*M* hydrogen peroxide

Reduced diphosphopyridine nucleotide (DPNH) was oxidized at a fairly rapid rate in the bacterial extracts with a trace of dye, which was needed to link the diaphorase with the pigment. Addition of hydrogen peroxide increased the rate of disappearance of the reduced nucleotide. This suggested that the organism would utilize two moles of reduced diphosphopyridine nucleotide: one reducing the pigment, and the second reacting with oxygen to form hydrogen peroxide. These would then react in a peroxidatic reaction yielding the oxidized pigment and water. Therefore, the following reaction scheme suggesting a physiological function for cytochrome *c* peroxidase is proposed:



Adaptation experiments provided more evidence supporting the above scheme. When the organism was grown under low oxygen tension, it was found to have a large amount of the pigment, peroxidase activity and catalase activity, and a moderate amount of diaphorase activity. Under high oxygen tension, only a trace of the pigment was observed, no peroxidase activity was found and the catalase activity was reduced, whereas the diaphorase activity increased (see Table 1). This suggests that under high oxygen tension a non-cytochrome system is in operation. At lower oxygen tension, the cytochrome system

Table 1

	Extracts of aerated cells	Extracts of non-aerated cells
Pigment*	< 0·01 per cent	*c.* 3·5 per cent
Cytochrome peroxidase†	12 units	830 units
Catalase‡	8 ,,	41 ,,
Diaphorase§	228 ,,	53 ,,

* The percentage, expressed in gm. per 100 gm. protein of the extract, was determined by assuming a minimum molecular weight of 14,000 for the pigment, as compared with animal cytochrome *c*.
† The units are expressed as a 0·01 change in optical density of the dye at 575 mμ per mgm. protein in 30 sec.
‡ The units are defined as the number of milli-equivalents of $NaBO_3.4H_2O$ decomposed per mgm. protein in 5 min. according to the method of Feinstein (ref. 5).
§ The units are expressed as a 0·01 change in optical density of the dye at 660 mμ per mgm. protein in 30 sec.

functions primarily. The appearance of this cytochrome system appears to be adaptive to low oxygen tension. This would be in agreement with Theorell's observation that the reduced yellow enzyme reacts with oxygen under high oxygen tension to form hydrogen peroxide, and with cytochrome *c* under low oxygen tension[4]. Further details of the nature of cytochrome *c* peroxidase activity and its physiological significance will be described elsewhere.

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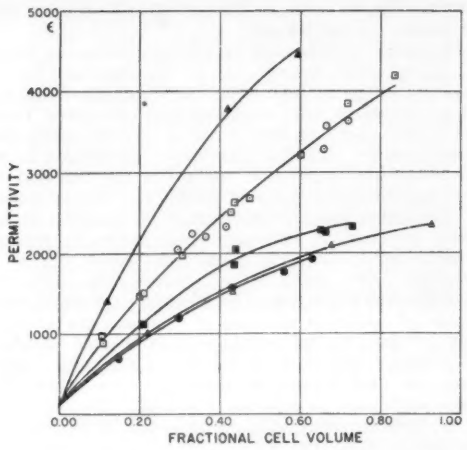
Relation of the Permittivity of Biological Cell Suspensions to Fractional Cell Volume

As was first shown in work on the red blood cell[1], the high permittivity (of the order of thousands) of biological cell materials is the result of an electric condenser action originating in an extremely thin section—possibly a bimolecular lipid layer—of the surface envelope, in which the principal part of the cell resistance is located. Under certain conditions, the capacity of this 'membrane' condenser can be calculated[2] from the observed permittivity and has been found to be closely the same for certain types of cell, namely, about 0·9 μF./sq. cm., in the radio-frequency region[1,3–5], corresponding to a probable thickness of the membrane of about 30 A. This calculation can be carried through rigorously only when the number of cells in the material is small. The analysis of denser cell materials raises the question of the form of the relationship between permittivity (ε) and fractional cell volume (ρ) in a system exhibiting this type of dielectric mechanism. Although this problem has been given some theoretical attention in the past, the only experimental data now available are those obtained in my early work on dog erythrocytes[1].

The accompanying graph shows results on suspensions of other cell species. The method used in measuring the permittivity of such systems, which are good conductors, has been described[6]. The frequency was 16 kc./s., which is within the region of nearly constant permittivity of all these cells, being above the low-frequency dispersion region found in some of them and below the high-frequency dispersion region, which represents the effect of the impedance elements in series with the membrane capacity[1,3].



	2a* (μ)	a/b*	C_m (μf./sq. cm.)	t_m/ϵ_m (A.)
⊙, Dog erythrocytes in serum	7·3	4·2	0·82	10·7
○, Rabbit erythrocytes in serum	7·3	4·0	0·82	10·7
△, Sheep erythrocytes in serum	5·2	2·9	0·85	10·4
■, Spherical rabbit erythrocytes in serum (20 mgm. lecithin per ml. serum)	4·7	1	1·07	8·3
▲, Rabbit leucocytes in 0·95 per cent sodium chloride (96 per cent polymorphonuclears, 4 per cent monocytes, ref. 7)	10·5	1	0·91	9·7
●, *Saccharomyces cerevisiæ* in 0·25 per cent sodium chloride (suspension approximately homogeneous in size, prepared from Fleishmann's yeast)	5·5	1	0·78	11·3

* 2*a*, 2*b*, axes of equivalent spheroid. Temp. 21·4° C.

The results can be summarized as follows. The form of an $\varepsilon \sim \rho$ graph does not depend on the absolute size of the cell, but on the shape of the cell, although not to a very marked degree. The different spherical cells have all the same form of graph, which is not significantly different from that of the relatively rounded erythrocytes of sheep; but these graphs level off faster than does the graph for the very flat erythrocytes of dog and

rabbit. The theoretical aspects of these results will be considered elsewhere.

In the legend are recorded also membrane capacity C_m (μf./sq. cm.) and ratio t_m/ε_m of membrane thickness to membrane permittivity of the cells, based on all observations now available and calculated from the initial slope of the $\varepsilon \sim \rho$ graph by using the formula of ref. 2. The membrane is assumed to be the same over the whole surface of the cell and to have negligible ionic conductance. The strict validity of the latter assumption cannot be established by direct experiment, although observations on packed cells showed that the membrane conductance is certainly very small in all these cells (data on erythrocytes in ref. 5). The formula contains a form factor (g) which in the case of a normal erythrocyte was obtained by taking the cell to be equivalent to an oblate spheroid (axes $2a$, $2b$) of the same major axis ($2a$) and volume as the cell. The other cells were calculated as spheres, $g = 2{\cdot}25$. The value $2a$ is an appropriately calculated mean of the microscopically measured diameters of a representative number of cells.

With the exception of the lecithinated erythrocyte, there is no significant difference between the values of t_m/ε_m for these different types of cell, indicating that both thickness and permittivity of the membrane are closely the same in all of them. In the frequency region above the experimental frequency (16 kc./s.), the frequency dispersion of the permittivity of the membrane of all these cells is very small and possibly the same in all of them[3,5]. Since lecithination results in more pronounced dispersion in this region[6] the permittivity of the lecithinated erythrocyte membrane at 16 kc./s. is probably higher than that of the normal membrane. This appears to offer a satisfactory explanation of the rather low value of t_m/ε_m for the lecithinated cell, without the necessity of assuming that the thickness of the membrane is substantially altered.

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[1] Fricke, H., *J. Gen. Physiol.*, **9**, 137 (1925).
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Influence of Hypophysectomy and of Adrenocorticotropic Hormone on a Mammalian Adaptive Enzyme System

The purification of a mammalian hepatic tryptophan peroxidase–oxidase system, and its properties, have been described by Knox and Mehler[1]. These authors demonstrated the system to be an adaptive one, increasing five- to ten-fold within 4–10 hr. following the intraperitoneal injection of massive doses of L-tryptophan[2]. That the adaptation is in fact real, with the increase in enzymatic activity resulting from a net synthesis of enzyme protein, has been discussed by Knox and Mehler[2], and also by Lee and Williams[3], who employed ethionine to inhibit the adaptation synthesis.

The important role of the pituitary in protein metabolism has been known for some time, and it was considered of interest to determine the effects of hypophysectomy on the ability of the rat to respond adaptively to injections of tryptophan. Normal male rats of the Long–Evans strain, weighing 120–140 gm., were used. Some animals were hypophysectomized at forty days of age, and were used four or fourteen days after operation, at which times their weights were in the range of the normal controls. All experimental animals were injected intraperitoneally with 0·7 mM L-tryptophan six hours before sacrifice. Controls were injected with saline. The rest of the experimental details follow the procedure of Knox[4].

The results presented in the accompanying table demonstrate the progressive failure of injected hypophysectomized animals to respond with an adaptive increase in the enzyme, although the static enzyme level is normal or greater than normal. By the fourth post-operative day, the injected animals give a response two-thirds of normal, and by the fourteenth post-operative day this response has decreased to one-third of the normal level.

Experimental group	μM Kynurenin formed per gm. liver per hr.
Normal controls (15)*	1·59 ± 0·10†
Hypophysect. controls[a] (18)	2·05 ± 0·14
Hypophysect. controls[b] (6)	2·20 ± 0·13
Normal injected (10)	16·2 ± 0·9
Hypophysect. injected[a] (9)	11·1 ± 0·6
Hypophysect. injected[b] (10)	5·4 ± 0·6

* Number of animals in parentheses.
† Mean ± standard error.
a, 4 days post-operative.
b, 14 days post-operative.

These results, which indicate the relative inability of the hypophysectomized animal to synthesize this enzyme, could also be explained as a consequence of any of the following conditions in these animals: decrease in formylase activity, increase in kynureninase activity, absence of enzyme activators, presence of enzyme inhibitors, and a decrease in a peroxide-generating reaction necessary to initiate the reactions with tryptophan. All these possibilities have been eliminated by suitable combinations of liver homogenates from normal and hypophysectomized animals. Additionally, the failure of significant quantities of formylkynurenin, anthranilic or kynurenic acids to accumulate was shown by spectrophotometric measurements at their absorption maxima.

No differences were observed between normal and sham-hypophysectomized animals, either in their static or adaptive enzyme levels. That the relative failure in the response of the hypophysectomized animal was not due to an earlier or later response was demonstrated by determinations made at intervals of 3, 6, 10, 15 and 24 hr. after injection.

Knox[4] demonstrated that the pituitary–adrenal axis was concerned with non-specific increases (that is, increases following injection of inductors other than tryptophan) in the activity of the enzyme system, since these effects disappeared after adrenalectomy. However, the magnitude of the adaptive response of the adrenalectomized animal to tryptophan was the same as that of the normal animal given tryptophan. If this is correct, then it would be expected that injections of the adrenocorticotropic

hormone should cause an increase in the static level of the enzyme. Normal animals were therefore injected with 20–30 U. of adrenocorticotropic hormone in gelatin six hours pre-sacrifice. Controls were injected solely with gelatin. A control value of $2{\cdot}15 \pm 0{\cdot}29$ μM kynurenin formed per gm. liver per hour was obtained in nine animals, whereas twelve animals receiving adrenocorticotropic hormone showed a level equivalent to $5{\cdot}11 \pm 0{\cdot}52$ μM. This increment was highly significant statistically.

Complete details of these and other experiments in which the role of pituitary hormones has been investigated will be reported elsewhere.

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Extraction of a Heparin-like Substance from Mast Cell Granules in Mouse Connective Tissue

VARIOUS workers, Holmgren, Wilander, Jorpes and recently Ehrich *et al.*, have shown that there is a relationship between the number of mast cells and the amount of heparin in a tissue[1–4]. Confirmation was added by Oliver *et al.*, who were able to extract fifty times as much heparin from a dog tumour composed predominantly of mast cells as from normal dog liver[5]. The present work suggests the presence of a heparin-like substance in mouse mast cell granules.

A convenient method has been found for the selective extraction of mast cell granules from mouse connective tissue. The skin was separated from the trunk, pinned out and the exposed subcutaneous fascia dissected away. The fascial tissue from fifty mice so obtained was placed in 50 ml. of sterile distilled water in a sterile stoppered bottle and shaken for 1–2 hr. at a maximal speed with a 'Towers' shaker.

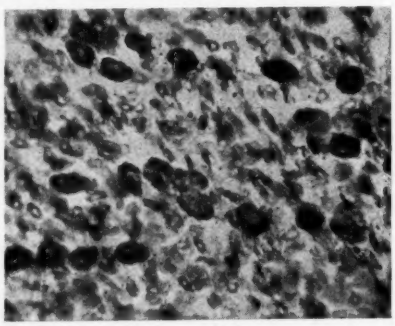

Fig. 1. Spread of subcutaneous connective tissue of a mouse, showing the normal mast cells and some free granules. Toluidine blue stain. (× *c.* 270)

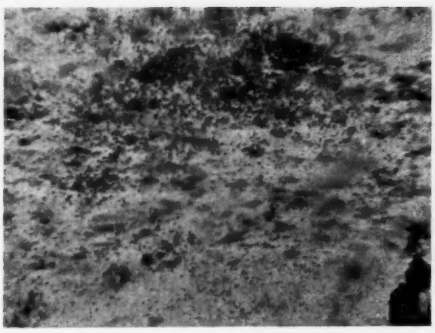

Fig. 2. Spread from the same tissue after shaking for 2 hr., showing a great number of free granules scattered throughout. Some disrupted mast cells can be seen near the top of the picture. Toluidine blue stain. (× *c.* 270)

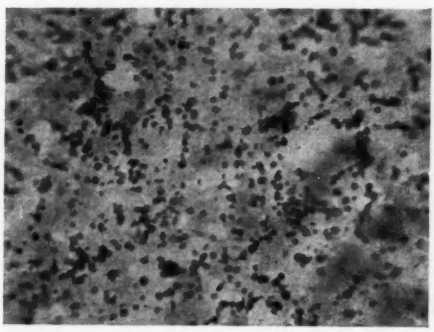

Fig. 3. Smear of the precipitate. Mast granules are seen of different size and shape. Toluidine blue stain. (× 570)

The fluid was removed with a sterile pipette and centrifuged at about 1,000 rev./min. for 10 min. The precipitate was found to consist predominantly of granules which stained metachromatically with toluidine blue (Fig. 3). Examination of the tissue after shaking showed that the majority of the mast cells were disrupted and, in addition to those granules which had been discharged into the fluid, others were diffusely spread throughout the tissue (Fig. 2).

No marked anti-coagulant effect was observed when the material containing the granules was added to fresh mouse blood. But after the material had been treated by the method for the extraction of heparin from tissues devised by Wilander[3], an anti-coagulant effect was demonstrated. About 2·5 mgm. of dried extract was rendered from 0·20 gm. of moist granule preparation. 0·5 mgm. of that extract, dissolved in 0·1 ml. of distilled water, inhibited the coagulation of 0·25 c.c. of fresh mouse blood for

Table 1. COAGULATION TIMES AND CORRESPONDING QUANTITIES OF THE EXTRACT

Extract (mgm. in 0·1 c.c. distilled water)	Mouse blood (c.c.)	Coagulation times
0·5	0·25	<48 hr.
0·25	0·25	20 min.
0·12	0·25	13 min.
0·06	0·25	10 min.
0·03	0·25	8 min.

longer than 48 hr. This solution, diluted two-, four-, eight- and sixteen-fold and mixed with blood in the same proportion by volume, delayed coagulation for 20, 13, 10 and 8 min., respectively, but normal clotting took place in the presence of a × 32 dilution. Table 1 shows the coagulation times and corresponding approximate quantities of the extract. The substance extracted from the granules gave a metachromatic reaction with subsequent precipitation with toluidine blue. These observations strongly suggest a resemblance of the extracted material to heparin.

I am indebted to Prof. R. D. Passey and Dr. T. D. Day for their encouragement and help and criticism, and wish to thank Mr. J. B. Kirkham, who provided the photomicrographs.

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Specificity of Complete Cold Auto-Agglutinins

Cold and warm auto-agglutinins exist. Both occur in the complete and incomplete forms. They are generally believed to be non-specific. Recently, doubt has been cast on their lack of specificity. I consider that (complete) auto-agglutinins might consist of multiple specific components[1-3]. Recently, Crawford, Cutbush and Mollison[4] have shown that incomplete cold auto-agglutinins present in all human sera have the specificity anti-*H*. The degree of sensitization of cells of various groups by these antibodies could be arranged in the following descending order, *O*—A_2—*B*—A_1—A_1B. Such reactions correspond to the relative amounts of *H* present in these various cells, *O* cells containing the most *H* and A_1B cells the least. Further, the action of incomplete cold auto-antibodies was inhibited by *H* substance, and their reactions closely agreed with those of an eel anti-*H* serum. Absorption of the antibodies in the cold by cells of various groups revealed that if A_1B cells are used the amount of antibody absorbed is inappreciable, whereas if *O* cells are used ability to sensitize group *O* cells or cells of groups A_1 and A_2 was completely abolished. These workers consider that the specificity of other non-specific antibodies needs to be re-examined. Davidsohn and Oyamada[5] have shown that the warm auto-agglutinins associated with hæmolytic anæmias are predominantly specific for the individual's own cells. Weiner *et al.*[6] have demonstrated that such an auto-agglutinin had the specificity anti-*e*.

The complete cold auto-agglutinins which are present in almost all Indian bloods were therefore re-investigated. For convenience *AB* bloods were examined as they do not contain iso-agglutinins. The sera were titrated against cells of groups A_1B, A_2B, A_1, A_2, *B* and *O*, and in each case against the patient's own cells. Typical results are reproduced in Table 1.

It is evident that the strengths of agglutination do not correspond to the expected amount of *H* agglutinogen in the various cells, and that these antibodies are not predominantly specific for the individual's own cells.

Table 1. Titres of Cold Agglutinins in an A_1B Serum against Various Cells at 4–6° C.

Cells	Activity of undiluted serum	Titre
A_1B	+++	8
A_1B	W	2
A_1	+++	8
A_2	+++	16
B	+++	128
O	+++	16
Own	+++	32

The antibodies did not give parallel reactions with an anti-*H* serum prepared by absorbing the serum of the Indian water buffalo with A_1B cells (water buffalo anti-*H* is more powerful than that prepared from Indian cattle). *H* substance (dried saliva of a group *O Le* (*a-b-*) secretor) produced some inhibition of the action of these antibodies on various cells. Similar inhibition was produced by the saliva of a group *O Le* (*a-b-*) non-secretor. The secretor saliva successfully inhibited the water buffalo anti-*H* but the non-secretor saliva did not. In some sera complete absorption with *O* cells failed to abolish activity upon other cells, and similar findings in certain other sera were obtained after absorption with the individual's own cells. Elution of the antibody from the cells used for the absorption gave inconclusive results.

The titration and absorption experiments indicate that the complete cold auto-agglutinins present in the sera of most Indians do not give the reactions expected of anti-*H*. This view is supported by the examination of the titration values of these cold agglutinins in a number of sera undertaken in connexion with another investigation (to be published). In this investigation complete cold agglutinins in the sera of Indians of all groups were titrated in parallel against *O* cells, compatible *A* or *B* cells and the individual's own cells. The results are summarized in Table 2.

Table 2

1st Series

Number of sera examined	100
Number of sera in which titres against *O* cells were higher than the individual's own	74
Number of sera in which the individual's own cells were agglutinated to higher titres than *O* cells	17
Number of sera showing equal activity against both *O* cells and the individual's own	6

2nd Series

Number of sera examined	81
Number showing highest titres against *O* cells	41
Number showing highest titres against compatible *A* or *B* cells	14
Number showing greatest activity against the individual's own cells	10
Number showing equal activity against all cells	16

While it appears that complete cold auto-agglutinins do not have the specificity anti-*H*, the possibility of anti-*H* being a component antibody cannot be excluded.

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[1] Bird, G. W. G., *Lancet*, **i**, 977 (1951).
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FORTHCOMING EVENTS

*(Meetings marked with an asterisk * are open to the public)*

Monday, October 19

INSTITUTION OF ELECTRICAL ENGINEERS (at Savoy Place, London, W.C.2), at 5.30 p.m.—Discussion on "Television".

INSTITUTE OF METAL FINISHING (joint meeting with the SOCIETY OF CHEMICAL INDUSTRY, CORROSION GROUP, at Burlington House, Piccadilly, London, W.1), at 6.30 p.m.—Mr. H. A. Holden: "The Phosphating of Steel Prior to Painting"; Mr. J. F. Andrew, Dr. S. G. Clarke and Dr. E. E. Longhurst: "The Protective Properties of Various Phosphate Coatings on Steel".

Tuesday, October 20

UNIVERSITY COLLEGE, LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Prof. J. B. S. Haldane, F.R.S.: "The Physiology of Diving".*

SOCIETY FOR APPLIED BACTERIOLOGY (in the Lecture Hall, Royal Society of Tropical Medicine and Hygiene, Manson House, 26 Portland Place, London, W.1), at 3 p.m.—Symposium on "Microbial Spoilage in Industrial Materials".

BONE AND TOOTH SOCIETY (at the Institute of Orthopædics, 234 Great Portland Street, London, W.1), at 5 p.m.—Symposium on "Bone and the Kidney". Dr. W. Sheldon: "General Introduction on Renal Function with regard to Bone Disease, including History of Renal Dwarfism and Rickets"; Dr. F. Harwood Stevenson: "Clinical Manifestations of Kidney-parathyroid-bone Relationship"; Prof. S. L. Baker: "Histology of Bone Disease with Impaired Renal Function"; Dr. C. E. Dent: "Normal Renal Functions which could Affect Bone Metabolism"; Dr. T. F. Dixon: "Biochemical Findings in Bone Disease of Renal Origin".

INSTITUTE OF PHYSICS, ELECTRONICS GROUP (at 47, Belgrave Square, London, S.W.1), at 5.30 p.m.—Dr. F. Ashworth: "Field Emission Phenomena".

INSTITUTION OF ELECTRICAL ENGINEERS, MEASUREMENTS SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. J. F. Coales: Chairman's Address.

INSTITUTE OF PHYSICS, EDUCATION GROUP (at the Royal Institution, Albemarle Street, London, W.1), at 6.30 p.m.—Prof. O. R. Frisch, F.R.S.: "Atomic Energy—How it all Began".

INSTITUTE OF BIOLOGY, LONDON BRANCH (at the Society for Visiting Scientists, 5 Old Burlington Street, London, W.1), at 7.30 p.m.—Dr. G. D. H. Bell: "Barley"; Mr. Frank Marshall: "Malt"; and Dr. J. H. Oliver: "Brewing".

ROYAL SOCIETY OF MEDICINE, PATHOLOGY SECTION (at 1 Wimpole Street, London, W.1), at 8 p.m.—Discussion on "The Applications of Histochemical Methods to Pathology".

Wednesday, October 21

GEOLOGICAL SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Prof. J. Z. Young, F.R.S.: "The Evolution of Vertebrate Organization" (William Smith Lecture).

ROYAL METEOROLOGICAL SOCIETY (at 49 Cromwell Road, South Kensington, London, S.W.7), at 5 p.m.—Scientific Papers.

ROYAL SOCIETY OF MEDICINE, COMPARATIVE MEDICINE SECTION (at 1 Wimpole Street, London, W.1), at 5 p.m.—Mr. T. J. Bosworth: "Control of Livestock Diseases in Britain: Some Reflections on the Present Situation" (Presidential Address).

ROYAL MICROSCOPICAL SOCIETY (at Tavistock House South, Tavistock Square, London, W.C.1), at 5.30 p.m.—Mr. J. Smiles: "Practical Microscopy—The Development of the Stage-Picture".

BRITISH PSYCHOLOGICAL SOCIETY, SOCIAL PSYCHOLOGY SECTION (in the Psychology Department, University College, Gower Street, London, W.C.1), at 8.15 p.m.—Mr. T. H. Pear: "Social Differences in English Sports and Games".

Thursday, October 22

UNIVERSITY COLLEGE, LONDON (in the Anatomy Theatre, Gower Street, London, W.C.1), at 1.15 p.m.—Dr. Randolph Quirk: "Careless Talk: Some Features of Everyday Speech".*

LINNEAN SOCIETY OF LONDON (at Burlington House, Piccadilly, London, W.1), at 5 p.m.—Dr. J. Heslop-Harrison: "The Genus *Dactylorchis* in Britain: a Problem of Variation".

INSTITUTION OF ELECTRICAL ENGINEERS, UTILIZATION SECTION (at Savoy Place, London, W.C.2), at 5.30 p.m.—Mr. B. L. Metcalf: Chairman's Address.

Thursday, October 22—Saturday, October 24

INSTITUTION OF METALLURGISTS (at Grosvenor House, Park Lane, London, W.1).—Platinum Metals Exhibition.*

Thursday, October 22—Sunday, October 25

COUNCIL FOR THE PRESERVATION OF RURAL ENGLAND (in conjunction with the COUNCIL FOR THE PRESERVATION OF RURAL WALES, at Malvern).—"The Countryside—Profit and Loss" (Fourteenth National Conference).

Friday, October 23

TEXTILE INSTITUTE (at 10 Blackfriars Street, Manchester 3), at 3 p.m.—Prof. E. Honegger (Switzerland): "Some Aspects of Textile Developments as Seen from Switzerland" (Emsley Lecture).

ROYAL ASTRONOMICAL SOCIETY (at Burlington House, Piccadilly, London, W.1), at 4.15 p.m.—Geophysical Discussion. "The Determination of the Geoid". Chairman: Dr. G. M. Lees, F.R.S.; Speakers: Dr. J. de Graaff Hunter, Brigadier G. Bomford and Dr. A. H. Cook (for Prof. Heiskanen).

PHYSICAL SOCIETY (at the Science Museum, Exhibition Road, London, S.W.7), at 5 p.m.—Prof. J. Bartels (Göttingen): "Chree's Influence on Present-day Geophysics".*

SOCIETY OF PUBLIC ANALYSTS AND OTHER ANALYTICAL CHEMISTS, PHYSICAL METHODS GROUP (in the Lecture Hall, The University, Southampton), at 5 p.m.—Scientific Papers.

INSTITUTE OF PHYSICS, INDUSTRIAL RADIOLOGY GROUP (at 47 Belgrave Square, London, S.W.1), at 6.30 p.m.—Dr. R. H. Herz: "Theory and Practice of Auto-radiography".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

ASSISTANT LECTURER (graduate in chemistry, biochemistry, physics or microbiology) for duties which will include the supervision of laboratory work—The Registrar, National College of Food Technology, Cranwood Street, City Road, London, E.C.1 (October 24).

ANALYTICAL CHEMIST (with at least B.Sc. degree, or equivalent qualification in chemistry) in the Health Department, Southern Rhodesia Government, to carry out the analysis of waters, food and drugs, dairy produce and certain chemical specimens; toxicology and forensic chemistry; general miscellaneous analyses—The Secretary, Southern Rhodesia Government, Rhodesia House, 429 Strand, London, W.C.2 (October 31).

ASSISTANT (preferably with pass degree or equivalent in botany or zoology, and practical experience in collection and identification of invertebrates) IN THE NATURE CONSERVANCY BIOLOGICAL RESEARCH STATION, Grange-over-Sands, Lancashire, for survey and experimental work on soil fauna in the field and laboratory—The Establishment Officer, The Nature Conservancy, 91 Victoria Street, London, S.W.1 (October 31).

ASSISTANT LECTURER (preferably with special qualifications or interests in stratigraphy) IN GEOLOGY—The Registrar, University College of North Staffordshire, Keele, Staffs (October 31).

PRINCIPAL SCIENTIFIC OFFICER (preferably with first- or second-class honours degree in chemistry, and good experience in modern metallurgical techniques) at the Ministry of Supply, Culcheth, Warrington, to take charge of staff providing analytical services to Metallurgical Research and Development Division—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting F.473/53A (October 31).

SCIENTIFIC OFFICER or SENIOR SCIENTIFIC OFFICER (with first- or second-class honours degree, and a good knowledge of physical chemistry), for (*a*) research on freshwater algæ, (*b*) research into the physical and chemical conditions in the bottom deposits in fresh waters, and the exchange of substances between these deposits and the overlying water—The Director, Freshwater Biological Association, The Ferry House, Ambleside, Westmorland (October 31).

LECTURER (with degree or recognized diploma in mining) IN THE DEPARTMENT OF MINING AND GEOLOGY—The Principal, Wigan and District Mining and Technical College, Wigan (November 2).

RESEARCH ASSISTANT (honours graduate in physics or mechanical engineering) to the Professor of Wool Textile Engineering, for fundamental studies of textile machinery and processes—The Registrar, The University, Leeds (November 2).

LECTURER (preferably with special interest in electronic and/or communication engineering) IN ELECTRICAL ENGINEERING—The Registrar, College of Technology, Manchester 1 (November 9).

CHAIR OF ELECTRICAL ENGINEERING, and CHAIR OF PHYSICS—The Registrar, University College of South Wales and Monmouthshire, Cathays Park, Cardiff (November 14).

LECTURER IN FORESTRY (preferably with emphasis on either forest mensuration and management or forest exploitation, utilization and timber technology)—The Secretary and Registrar, University College of North Wales, Bangor (November 15).

DEMONSTRATOR IN AGRICULTURAL CHEMISTRY—The Registrar, The University, Leeds 2 (November 16).

CHAIR OF ORGANIC CHEMISTRY—The Secretary, Queen's University, Belfast (December 3).

ASSISTANT PHYSICIST, basic grade (with honours degree in physics, and preferably with previous hospital experience) for duties in the Radiotherapy and X-Ray Diagnostic Departments—The Personnel Officer, St. Thomas's Hospital, London, S.E.1.

ASSISTANT LECTURER IN CHEMISTRY—The Registrar, University College, Leicester.

BIOCHEMIST, basic grade (B.Sc. or equivalent, and preferably with experience in tissue metabolism studies) in the Research Department—The Director of Research, Barrow Hospital, Barrow Gurney, near Bristol.

CHIEF INSTRUMENT ENGINEER (with A.M.I.Mech.E., A.M.I.E.E., A.Inst.P., or equivalent) to take charge of an Instrument Design Team at Risley, and an Instrument Development Centre at Capenhurst—The Ministry of Supply, Division of Atomic Energy (Production), Risley, Warrington, quoting 498.

ENTOMOLOGIST (with university qualification with biology or entomology as a special subject, and preferably with some experience in taxonomy of Culicidæ) in the Malaria Service of the Medical Department, Government of Nigeria—The Director of Recruitment (Colonial Service), Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting CDE.117/14/014.

GRADUATE (preferably with some knowledge of the steel industry) to undertake research on the flow of technical information in the steel industry—The Personnel Officer, British Iron and Steel Research Association, 11 Park Lane, London, W.1, quoting "Information".

JOSEPH HUNTER CHAIR OF PATHOLOGY—The Registrar, The University, Sheffield.

LECTURER (with good honours degree in mining engineering, and wide knowledge of mining ventilation and fluid mechanics) IN MINING ENGINEERING—The Registrar, The University, Nottingham.

PHYSICISTS or MATHEMATICIANS, Senior Scientific Officers or Scientific Officers (with first- or second-class honours degree or equivalent in physics or mathematics), for (*a*) to lead small team engaged in analysis of photographic observations, and be responsible for both measurement and interpretation of records and to carry out research on methods of obtaining maximum information from existing photographic instruments; (*b*) to take charge of optical laboratory and to undertake optical design associated with high-speed photographic systems (Ref. A.258/53A). Assistant Experimental Officer (with at least H.S.C. (science) or equivalent) to measure and assess photographic records, and practical work connected with calibration of photographic instruments (Ref. A.259/53A), at the Ministry of Supply Atomic Weapons Research Establishment, Fort Halstead, Kent—The Ministry of Labour and National Service, Technical and Scientific Register (K), 26 King Street, London, S.W.1, quoting appropriate Ref. No.

PLANT PHYSIOLOGIST (with good honours degree and with post-graduate research experience) to direct and undertake fundamental biochemical investigations with a view to the ultimate development of mass culture techniques for the lesser known marine algæ of potential industrial value—The Secretary, Institute of Seaweed Research, Inveresk, Midlothian.

SCIENTIFIC OFFICER (with honours degree or equivalent in mechanical engineering, and preferably with experience in agriculture) with the British Society for Research in Agricultural Engineering—The Scottish Machinery Testing Station, Howden, Mid Calder, Midlothian.

SOIL SCIENTIST (with good honours degree in geography with bias towards physical geography, and sufficient knowledge of chemistry to undertake a course in soil science) in the Department of Agriculture, Nigeria, for work on classification and mapping of soils—The Director of Recruitment, Colonial Office, Great Smith Street, London, S.W.1, quoting CDE.63/14/58.

REPORTS and other PUBLICATIONS

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The University of Nottingham. Plant Products and their Utilisation. (Twenty-sixth Sir Jesse Boot Foundation Lecture, 1952–3.) By Sir John L. Simonsen, Kt., D.Sc., F.R.I.C., F.R.S. Pp. 12. (Nottingham: The University, 1953.) 1*s*. 6*d*. [317

Ministry of Housing and Local Government. Department of Health for Scotland. Alkali &c. Works Regulation Act, 1906, and Alkali &c. Works Orders 1928–1950. Alkali &c. Works Regulation (Scotland) Acts 1906 and 1951. Eighty-Ninth Annual Report on Alkali &c. Works, by the Chief Inspectors, 1952. Pp. 74. (London: H.M. Stationery Office, 1953.) 2*s*. 6*d*. net. [317

Mushroom Research Association Limited. Report for the Year 1952. Pp. 50. (Yaxley, Peterborough: Mushroom Research Association, Limited, 1953.) 5*s*. [48

Forestry Commission. Census Report No. 2: Hedgerow and Park Timber and Woods Under Five Acres, 1951. Pp. 88+12 plates. (London: H.M. Stationery Office, 1953.) 5*s*. net. [48

The University of Nottingham. Geology and Time. By Prof. Leonard Hawkes, D.Sc., F.R.S. (Twenty-first Abbott Memorial Lecture.) Pp. 16. (Nottingham: The University, 1953.) 1*s*. 6*d*. [48

Falkland Islands Dependencies Survey. Scientific Reports. No. 1: Organisation and Methods. By Dr. V. E. Fuchs. Pp. 12+3 plates. 4*s*. 6*d*. net. No. 2: A New Method of Age Determination in Mammals, with special Reference to the Elephant Seal (*Mirounga leonina*, Linn.). By R. M. Laws. Pp. 11+1 plate. 3*s*. net. No. 3: The Upper Cretaceous Cephalopod Fauna of Graham Land. By Dr. L. F. Spath, F.R.S. Pp. 60+13 plates. 30*s*. net. No. 4: Lower Cretaceous Gastropoda, Lamellibranchia and Annelida from Alexander I Land (Falkland Islands Dependencies). By Dr. L. R. Cox, F.R.S. Pp. 14+2 plates. 5*s*. 6*d*. net. No. 5: Fossil Penguins from the Mid-Tertiary of Seymour Island. By B. J. Marples. Pp. 15+2 plates. 5*s*. 6*d*. net. (London: H.M. Stationery Office, 1953.) [48

Air Ministry. Meteorological Office. Professional Notes No. 107: Upper Air Circulation in Low Latitudes in Relation to certain Climatological Discontinuities. By R. Frost. Pp. 25. (Seventh Number of Vol. 7.) (London: H.M. Stationery Office, 1953.) 1*s*. net. [68

West African Cacao Research Institute, Tafo, Gold Coast. Annual Report, April 1950 to March 1951. Pp. 63. 5*s*. Annual Report, April 1951 to March 1952. Pp. 54. 5*s*. (London: Crown Agents for the Colonies, 1953.) [68

Federation of British Industries. Report of the Third Conference of Industrial Research Directors and Managers. Ashorne Hill, 1953. Pp. vi+70. (London: Federation of British Industries, 1953.) 3*s*. 6*d*. [68

Index of Theses Accepted for Higher Degrees in the Universities of Great Britain and Ireland. Vol. 1: 1950–51. Edited by P. D. Record. Pp. xii+157. (London: Aslib, 1953.) 25*s*.; 21*s*. to members. [68

A Hundred Years of Spectroscopy. By Prof. Herbert Dingle. (Being the Fifty Third Robert Boyle Lecture, delivered before the Oxford University Scientific Club, Trinity Term, 1951.) Pp. iv+23. (Oxford: Blackwell Scientific Publications, 1953.) 2*s*. 6*d*. net. [78

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Forestry Commission. Census Report No. 4: Census of Woodlands 1947–49, Woods of Five Acres and Over. Scottish County Details. Pp. vii+187. 10*s*. net. Report on Forest Research for the Year Ending March 1952. Pp. vi+130+8 plates. 4*s*. 6*d*. net. (London: H.M. Stationery Office, 1953.) [128

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